SPARK

REPORT

STRATEGIC
PLANNING
FOR
APPLIED
RESEARCH
AND
KNOWLEDGE

Science
Council of
British
Columbia

HEALTH CARE COMMITTEE
PLANNING REPORT

PREPARED FOR
THE SCIENCE COUNCIL OF BRITISH COLUMBIA
DECEMBER 1988

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EXECUTIVE SUMMARY

The Health Care Sector of the British Columbia economy was recognized by the Science Council of B.C. as an important element in its sector planning for science and technology in the British Columbia economy. A committee representative of all of the interested groups in the province and involving the National Research Council has met during the past few months and has identified strategic opportunities for the application of science and technology in this sector. The committee has not analyzed the status of basic and clinical research in the province as this is not the mandate of the Science Council of B.C.

The Health Care Sector in Canada is currently approaching $35 Billion a year in annual expenditures and growing at a constant dollar figure of 5% per year. In British Columbia, costs are approximately $4 Billion dollars and employment is approximately 75,000 people. The demands on the system are increasing as the population ages in this province and therefore science and technology could be useful in helping to contain costs, in stimulating economic development and continuing the excellent health care system currently available.

The committee identified major opportunities in the area of biomedical engineering and devices where the province has a world renowned expertise and where currently it imports the majority of these products into the province. Therefore, an opportunity exists to build on this expertise in the hospitals, the universities and industry to provide a significant part of the British Columbia requirements and to compete on a worldwide basis.

The committee also identified a major opportunity to coordinate the activities of the B.C. Health Care Research Foundation and the Science Council of B.C. in the applied research area and to jointly administer the $2.9 Million a year available to this province for medical research from the recently changed Patent Act.

The committee also suggests that significant opportunities exist in applying science and technology to the home care area which would also provide an opportunity to involve the nursing group in the development of health care delivery systems for this growing and cost effective care area. The rehabilitation area also provides an opportunity to apply science and technology to the task of making the province's disabled population more independent and to build on the significant social awareness for the disabled that has been achieved in British Columbia.

The committee also recommends that initiatives should take place to undertake phase 1 clinical tests in the province and expand into a larger pharmaceutical industry in this province.

In terms of the information technology area, the committee recommends a focus on improved costing systems, lifetime personal records for patients and in the longer term, developing standards for information technology.

The committee also recommends continuing networking between the province, the National Research Council and other interested parties in firming up on joint activities to focus on the application of technology for the expansion of economic activity and the containment of costs in health care delivery. The committee suggests that a joint initiative in certain aspects of this activity might be beneficial to the province.

The committee identifies the need to balance the sometimes conflicting objectives of improving quality of service, improving safety, containing costs and developing the economy. The growing use of science and technology has the potential to assist in achieving all of these objectives and also to capitalize on the large potential market in B.C., in Canada, in the U.S. and worldwide for health care products, devices, services and systems.

The committee recommends that it continue to perform an ongoing role of monitoring implementation into the next phase to ensure that the recommendations are implemented or developed further into specific proposals.

INTRODUCTION

The Science Council of British Columbia established a series of sectoral planning committees in early September 1987, based on its already existing AGAR Grant committees, to identify opportunities for improving the application of science and technology to the economy of British Columbia. These committees comprise representatives of industry, universities, institutes and colleges, research institutions and government, and are to develop specific sectoral plans for the application of science and technology. The recommendations of each committee will then be reviewed and priorities established by Science Council and integrated into overall plans for science and technology by the Premier's Advisory Council on Science and Technology and by the provincial government.

These sectoral plans are aimed to identify key strengths and weaknesses and to make broad recommendations. Detailed investigations of specific opportunities or resolution of problems identified will occur subsequently once priorities have been established.

The following individuals were members of the Health Care Sector Planning Committee:

Dr. Joan Anderson	School of Nursing, UBC
Mr. Gary Birch	Neil Squire Foundation
Dr. Pieter Cullis	Canadian Liposome Co. Ltd.
Dr. Stephen Drance	B.C. Health Care Research Foundation
Ms. Deborah George	Ministry Advanced Education and Job Training
Mr. Brian Gillespie	School of Health Science, B.C.I.T.
Ms. Elaine Kozak	Ministry of Economic Development
Dr. Morton D. Low	Health Sciences, UBC
Dean Axel Meisen	Faculty of Applied Science, UBC
Dr. Jim McEwen	Andronic Devices Ltd.
Mr. Paul Pallan	Ministry of Health
Mr. Paul Rummell	Peat Marwick
Dr. Martha Salcudean	University of British Columbia
Mr. Peter Warwick	Campbell River & District General Hospital
Mr. John Witt	Western Management Consultants

BACKGROUND INFORMATION

We describe in this section of the report the overall picture for health care within Canada, some trends that are emerging within the country and the possible role for technology development in that picture. We then describe more specifically the British Columbia scene regarding health care and the specific needs identified in British Columbia for technology.

Health Care in Canada

The annual expenditures in the Canadian health care sector are now over $35 Billion per year and are increasing at a rate of at least 5% per year in constant dollars. Of this total of $35 Billion, $1.8 Billion is used to acquire medical devices, three quarters of which are imported. The sector involves all levels of government plus institutions, health care professionals, support staff, scientists, engineers, academics, manufacturers and suppliers.

The Canadian health care system is regarded on a worldwide basis as one of the best in the world. However, there is increasing concern about future cost pressures that will be faced by the health care system. One major trend impacting on this health care system deals with the growing number of older people in the population and their ongoing requirements of the health care system. There is evidence of a significant increase in the rate of utilization of health care services of this aging population in the later years of their life. This increase is particularly evident in the use of hospital facilities.

The result is a dramatically increasing cost of care per patient during the last few years of their life. This, coupled with an increasing number of older people, causes a significant increase in the total cost for this aging group.

The Commercial Health Care Industry in Canada

At present, there are over 400 Canadian companies involved in the manufacture and distribution of health care products and also an increasing number of Canadian high technology companies are looking at the health care market as a possible area for expansion. However, the total development and production of health care products within Canada is a significantly smaller industry than the market could support. In 1981, Canada spent $1.8 Billion on medical devices and this market has been growing at an annual rate of 11%. In 1981, 80% of these devices were imported. Therefore, it is clear that a major opportunity exists to make Canada more self sufficient in this large dollar expenditure area and also to give the industry an opportunity to compete internationally in a market that on a worldwide basis is also very significant. In 1980, $15 Billion per annum was spent on health related research and development of which the Canadian share was just over 2%. Clearly, there are opportunities then on a worldwide and national basis to expand the role of Canadian research and development in health care.

Health Care in British Columbia

Within British Columbia, the health care sector is one of the major sectors of activity within the provincial economy. The annual budget in 1987-1988 was $3.2 Billion and provided employment to 75,000 people. This province is also faced with the demographic changes indicated for Canada as a whole with a growing population increase in the older age group. Our current percentages of population are 37.6% under 18, 49.8% between 18 and 64 and 12.7% over 65. In addition to the normal demographics, British Columbia is faced with a net importation of older people to this province as they seek pleasant weather and surroundings for their retiring years. As in Canada as a whole, the largest cost element in the health care system continues to be labour and therefore any improvements in technology have to focus on containing the increase in labour requirements on an annual basis.

British Columbia has a small and emerging industry in health care manufacture and supply. However, it is an even larger net importer of these products and services in Canada as a whole as it does import also from Eastern Canada to fill its needs.

Health Care Research in British Columbia

The bulk of health care research in British Columbia has been focussed on basic and clinical research as opposed to research into products and services that could bring technological developments to this industry or could assist in the cost containment requirement identified in the background information. In 1986-87, 41.1% of the funding for health care research in the province came from the Medical Research Council, 11.9% from the B.C. Health Care Research Foundation (provincial government funding), 8% from the National Cancer Institute, 6.1% from the Heart Foundation and the very largest share of these funds were devoted to basic and clinical research. A small part of the budget for the B.C. Health Care Research Foundation is devoted to seeking applied research opportunities that could lead to the commercial application of products and services. A table is enclosed as Appendix A listing the sources of funding for health care research in British Columbia.

The B.C. Health Care Research Foundation was established as a non-profit society in 1977 to act as an agency for the allocation of lottery fund proceeds to medical research in the province. It has operated since then with an annual budget starting at $2.7 Million and leading now to approximately $4 Million. It functions with a peer review process to review applications and allocate its priorities based on three areas which are basic research, clinical research and applied research. It has also added the fields of community health care delivery and clinical studies as part of its priorities. It provides it's funding through research operating grants, research scholarship awards and development and training fellowships. In practice, the bulk of its funds have been allocated in the past to the first two areas of activity namely, basic science and clinical research and to date, a minimal amount of funding has been provided for applied research activities. It funds approximately half of the requests it receives each year and is able only to fund small projects with an average funding level of $23,000 whereas many projects require $100,000 to $200,000 per year (Appendix B).

IDENTIFIED NEEDS IN HEALTH CARE RESEARCH IN BRITISH COLUMBIA

Primarily the committee feels that strategies should be developed that would address the identified elements of the health care system in this province. Firstly, the growing cost of health care delivery must receive attention. Our present health care system is regarded as one of the best in the world. However, if its costs are not contained, then this system will inevitably suffer. Secondly, the basic elements of the demographic trends and patterns of health care delivery have to be recognized when developing priorities for research and development in this sector. The population in this province is aging significantly and this aging population is receiving a higher percentage of its lifetime health care delivery in the final few years of its life span. This is posing increasing burdens on the health care facilities and work force. Thirdly, opportunities exist due to the large annual expenditures in this sector for the development of a British Columbia industry. This local industry could offset the net importation of medical devices and produce more of the products and services required in British Columbia and could also become a significant worldwide exporter of such products and services in a growing market on a worldwide basis.

Biomedical Devices

Specifically, the committee identifies a need to focus on biomedical devices as a potential area of growth within this province (Appendix C). This is a significantly large element in the total cost picture, the province has a growing group of acknowledged experts in this field and an emerging industrial sector to interact with their experts. In Canada, the annual expenditures on medical devices is $1.8 Billion, of which three quarters are imported. There is a relatively small export activity now which could be significantly expanded. The major hospitals in the province, together with U.B.C., have an acknowledged leadership role in selected areas and are also producing a flow of innovative graduates to key roles in hospitals, universities and industry. There is a need to orient the manufacturers in B.C. to the opportunities and guidelines for health care products and devices so that they can participate actively in this growing market.

The annual expenditures on medical research in Canada are over $300 Million which need to be capitalized on in terms of products and devices to build an industrial base. This expenditure is growing at over 20% per year.

There is a need to identify the training requirements in universities and colleges in the province in this potentially expanding field so that locally trained people are available to staff the opportunities that emerge.

Coordinated Approach

The committee feels strongly that in order to develop science and technology in the applied side of the health care system, efforts must be made to bring this sector into the mainstream of science and technology activity in the province. This would require some efforts to coordinate more the activities of the B.C. Health Care Research Foundation and the Science Council of British Columbia so that a coordinated approach could be made to the application of science and technology to this sector. This is particularly important when funding requests are made to the federal government so that these could be on a coordinated basis. Currently, a coordinated approach is required to secure the $2.9 Million annual funds recommended for health care research in British Columbia due to changes in the Patent Act. The other sectors of the British Columbia economy such as the Information Technology sector, the Biotechnology sector, the Manufacturing sector and the Applied Materials sector must all properly interface with the Health Care sector to identify opportunities for science and technology through the interaction of these sectors with the Health Care sector.

Home Care

The committee recognizes that with the growing group of older and chronically ill people in this province and the focus of their health care requirements in the later years of their lives, increased emphasis will be required on home care. Opportunities exist to apply science and technology to this area and to involve the nursing profession, medical practitioners, the medical devices group and the information technology area in coming up with cost effective patient delivery systems.

Hospitals

The hospital environment represents the largest component of the health care budget. It is characterized by increased acuity levels while, at the same time, being faced with shortages of qualified health care professionals. These competing factors make it essential to find ways of working more productively and represent a major opportunity for identifying more efficient methods of delivering health care.

For example, the interaction of various professional groups throughout an institution could be improved through the intelligent application of technology. Considering the rapid evolution of the industry, there is a need for providing more productive tools for updating the professional skills and knowledge base. These automated tools could be extended to patients and family members who currently require individualized teaching by health care professionals. Artificial intelligence and integrated information systems represent a major opportunity for improving clinical and administrative decision making.

Rehabilitation

The committee recognizes that a need exists to apply science and technology to the large group of people in this province who require specialized products and services so that they may become more self sufficient in the conduct of their activities. The committee feels that this province has a particular advantage over other areas of Canada in this regard as the handicapped group in the population have significant focus at this time and are poised to play their role in the joint development of improved approaches.

Pharmaceutical Industry

The committee recognizes that at present, British Columbia does not have a major pharmaceutical activity and yet has a worldwide reputation particularly in the cancer research area that could support the development of a clinical testing activity which could then lead to the growth of a pharmaceutical activity in the province.

Information Technology

Major opportunities exist to develop information technology into the health care field. These, in the committee's view, involve the development of lifetime records for patients, the development of costing systems that provide information on the cost of particular treatments and patients and also information systems that could reduce the amount of paperwork that medical practitioners are involved with and allow them more time to deal with patients and to provide health care. The committee sees information technology providing major inputs into all of the needs identified above, the medical devices area, the coordinated approach, the home care delivery system, the rehabilitation approach and the pharmaceutical area.

There are currently a number of alternative information systems available in B.C. for hospitals including those developed by C.H.A., by the B.C. hospitals collectively, by individual hospitals and by private firms. Reviews are ongoing to ensure that common data is available for planning and monitoring purposes for these systems.

In the Spring of 1989, electronic billing will be implemented for doctors and will require the use of cards for all people in the province. This provides a significant opportunity to move this information requirement forward.

Balancing Objectives

The committee recognizes that improvements in health care delivery resulting from the further use of science technology impact in a variety of ways. Potentially these are in four areas:

- quality of service provided
- safety of patients and health care practitioners
- cost containment
- economic development

A balance is needed at all times between these conflicting objectives to ensure that one does not provide a detrimental effect on other objectives. The committee feels strongly that further uses of science and technology can potentially provide benefits in all four of these areas.

Quality of Service Provided

Technological advances clearly impact on the quality of service in all areas of health care delivery. These advances have to be weighed carefully in relation to cost. Many will provide economic development opportunities through the creation of manufacturing opportunities here in B.C.

Safety of Patients and Health Care Practitioners

Advances in science and technology are enabling better evaluation and monitoring systems to be implemented, again these must be cost evaluated and economic opportunities identified.

Cost Management

The committee recognizes the potential importance of technological developments in attempting to contain the costs of health care. It supports the continuing involvement between the province, the National Research Council and other interested parties in firming up on joint activities to focus on the application of technology for economic development and the management of costs in health care delivery. The committee feels that a joint initiative in certain aspects of this activity might be beneficial to the province.

Economic Development

The committee feels strongly that the large size of the potential market for health care products, devices and systems in B.C., in Canada, in the U.S.A. and internationally, provides an excellent opportunity for economic development in B.C. As outlined in this report and in the appendices, these opportunities exist in biomedical engineering and devices, in rehabilitation products and services, in home, chronic, acute and community care, in information services and in pharmaceutical products.

The committee supports the overall recommendation of the SPARK report emphasizing the need for ongoing review of venture capital funding for technology companies in B.C.

Training and Technology

The committee recognizes that people development and training are major elements in health care delivery. This report does not attempt to cover this large area, however it does recognize that particular training is required for health care practitioners in the new and emerging technologies and equipment so that the full rewards can be realized. This requires coordination and planning between those developing the technologies and the teaching and training organizations in universities and colleges.

In addition, opportunities will develop to utilize technology in the actual delivery of training, both first hand and remotely in order to reach the health care practitioners.

RECOMMENDATIONS

In order for science and technology to more fully impact on the very important health care sector in British Columbia, the committee makes recommendations in the following areas:

1. Biomedical Engineering
2. Coordinated Approach to Health Care Research
3. Home Care Delivery
4. Hospitals
5. Rehabilitation Products and Services
6. Pharmaceutical Developments
7. Information Technology
8. Economic Development
9. Implementation

The committee places its highest priority on the first two of these recommendations, the support for the current initiative on biomedical engineering and the need for a coordinated approach to applied science and technology in health care in this province. Its other recommendations then follow in equal priority and the committee supports the commencement of activities in each of these areas in order to provide the health care industry with a much higher impact of science and technology.

1. Biomedical Engineering

The committee supports the initiative attached as Appendix D which has been developed jointly between a number of the major hospitals, the universities and the emerging biomedical industry in this province. The committee feels that the combination of the major opportunity presented by the annual expenditures on biomedical devices in British Columbia and the acknowledged expertise that resides in the province provides an ideal growth opportunity for a new industry within this province that could not only satisfy British Columbia requirements, but become an exporter within Canada and other parts of the world.

2. Coordinated Approach on Health Care Research

The committee strongly encourages B.C. Health Care Research Foundation and the Science Council of B.C. to coordinate their activities in the applied research area so that a joint position can be put forward to federal funding agencies. In addition, this coordinated approach will allow for the interaction of the health care sector with the other major sectors of the Science Council's activity namely information technology, biotechnology, advanced materials and manufacturing.

A particular need was identified to coordinate approaches by all parties within this province, including various ministries of the provincial government, to recover from general revenues the $2.9 Million per year in each of the next four years that has been allocated for health care research by the federal government as part of its change in legislation on the Patent Act (Appendix E). This funding is directly attributable to and allocated for health care research in this province based on a population formula. Efforts were made to see this funding removed from general provincial revenues on an annual basis.

A joint proposal was agreed by the Science Council of B.C., the B.C. Health Care Research Foundation, the universities and the relevant provincial departments for the application of these funds. The joint agreement proposed that the annual $2.9 Million be allocated to a new program to be developed and administered jointly by the Science Council of B.C. and the B.C. Health Care Research Foundation for the specific purpose of investing in applied research and development in health care in British Columbia. This funding is intended to continue until March 31, 1991 and would provide a major increase in the funds available for health care applied research in this province.

The provincial government has responded positively to this joint proposal. The Cabinet has agreed to allocate the annual $2.9 Million to health research to be administered jointly by the B.C. Health Care Research Foundation and Science Council. Details of this program are now being worked out.

3. Home Health Care

As indicated in this report to date, a growing area of requirement in health care delivery continues to be the aging and chronically ill population and their requirements in the later years of their lives. A significant cost saving is available to the province if these people are cared for in their homes as opposed to hospitals and other health care institutions.

A proposal (Appendix F) has been developed jointly by the University of British Columbia School of Nursing and the Vancouver Health Department that would investigate ways to bring science and technology to this growing health care area. Other groups have also collaborated, including various elements of the industry within British Columbia. The committee feels strongly that this initiative should now be supported as it would not only address a particular identified need within British Columbia, but would also allow a major opportunity for the nursing sector of the health care delivery system to actively participate in the development of science and technology within the health care system. The nurses make up the largest single group of people involved with the health care system and are a key part of the system directly involved with the patient.

Therefore, the committee strongly supports the initiative described in Appendix F which would focus technology development on information management at the systems level and patient teaching in the home, these two being viewed as the primary areas of focus at this time. This initiative would also provide a good interaction between the nursing profession, the biomedical devices providers and the information technology sector to jointly focus on the cost effective provision of patient care in the home.

4. Rehabilitation Technologies

The committee supports the initiatives (Appendix G) developed within British Columbia for a focus of science and technology on the disabled within this province. The focus of this initiative would be to develop products and services that could make the disabled population of this province more self sufficient and able to function more independently. The committee feels that a focussed effort that pulls together all of those involved with providing services to the disabled could build on the high profile within this province that has been established for this group. The present social awareness and acceptance of the disabled is viewed as being the best in the world within British Columbia.

However, to date this group have not themselves had opportunities to participate in the development of science and technology as the consumer. Therefore, the committee recommends an approach that would pull together the various agencies involved in the provision of research for the disabled, would allow a role for the consumer to actively identify their needs and would put a focus on this sector immediately. In addition, the committee identified the need for a graduate program in Rehabilitation Medicine which could act as a specific academic body that could coordinate and promote many aspects of research related to rehabilitation.

5. Development of a Pharmaceutical Industry

In order to develop a pharmaceutical industry within British Columbia, two major initiatives are required. Firstly, the ability to undertake phase 1 clinical trials for anti-cancer and other drugs and secondly, the provision of a pilot plant facility for the local manufacture of the pharmaceuticals for these trials. Presently, phase 2 testing (checking the efficacy of the drug for treatment of specific cancers) and phase 3 testing (comparing the efficacy of the new drug to that obtained with present treatment protocols) are both available in British Columbia. However, no facilities and expertise for phase 1 trials, which involve toxicity testing and establishing the maximum dose levels that can be applied, are available in this province.

As an example, the B.C. Cancer Control Agency (BCCCA) has a significant international reputation in Canada in cancer trials and also a large group of patients that it can use for testing. The opportunity therefore exists to expand into this area of phase 1 testing which is believed to have a major growth potential based on recent changes to the pharmaceutical legislation within Canada. This is estimated to make available approximately $10 to $15 Million per year for research and development in this particular field (Appendix M).

The requirements of the BCCCA are for a clinical pharmacologist to be hired with a research nurse and some auxiliary space and equipment. This would cost approximately $150,000 per year. Similar facilities in other hospitals, e.g. University Hospital, Children's Hospital and the Vancouver General Hospital to test other drugs could be included in a comprehensive clinical trial group which would be able to take any drug from phase 1, through phase 3 trials in collaboration with the pharmaceutical industry.

A second requirement in this area is for a clean room facility which would allow the manufacture of tested drugs here in this province. The probable cost of such a facility would be in the $850,000 area. The committee is currently recommending as a first stage, the hiring of staff required for the phase 1 testing with a subsequent review in more depth of the needs and costs of providing the clean room facility (Appendix H). The clean room facility could possibly be obtained in cooperation with U.B.C.

6. Information Technology

The committee recognizes the growing need for developments in the information technology area related to health care services and particularly identifies the role of the information technology sector in its previous recommendations concerning biomedical engineering, the coordinated approach of those involved with health care research, the home care delivery recommendation, the rehabilitation recommendation and the pharmaceutical recommendation. All of these will require an element of information technology in order to be effective.

In addition to these, the committee feels that emphasis should be encouraged in three primary areas: Firstly, in the cost accounting area (Appendix I) so that specific costs of services, patients and programs can be identified within hospitals and within the British Columbia health care system. In this way, significant improvements may occur in containing costs and focussing on those improvements that will benefit the sector. Secondly, the committee recognizes a need for a personal lifetime electronic health record (Appendix J) and encourages British Columbia to take a leadership role in the initial feasibility studies in this area. Thirdly, the committee encourages a continuing role for this province in the much longer term evolution of standards within North America for the reporting and controlling of health care costs (Appendix K). These initiatives are currently underway within North America and require continuing support from the province.

Within the hospital environment, the capture of patient data at source is the primary mechanism by which the vast and varied information required to provide efficient and cost effective health care can be managed. In the past 5 years the technical forces of distributed processing, affordable computing power, improvements in data entry techniques, and the ergonomic designs of terminals have made bedside data capture a practical alternative to paper record keeping. The benefits of capturing data where transactions are generated include improved accuracy, legibility and consistency of patient records, easier access to patient information in the location where it is most needed, immediate access to diagnostic results, and integration of clinical and administrative information.

Long term benefits include the use of decision support functions and the creation of an electronic lifetime clinical record. While there is no limit to the number of departments that could derive benefits, or to the kinds of functions which an automated hospital information system can perform, studies assessing the impact of a computerized system on direct patient care are lacking.

Some development has taken place in the area of nursing information systems but there are few published studies examining the results. This subject matter is timely and critical. Today, patient care information systems are required by hospitals to communicate and document patient care as well as to assess productivity. A system such as that being developed by the Vancouver General Hospital Nursing Division, in collaboration with the Hospital Information Systems Department and Biomedical Engineering (see Appendix M), if accurately investigated, analyzed, and reported, has the potential to be used as a model for other hospitals in British Columbia and other provinces in Canada.

7. Overall Objectives

The committee also recommends that technological developments in health care delivery impact on the quality of service, safety, cost containment and economic development. An appropriate balance is required of these four, often competing, objectives. The committee recommends strongly that science and technology can be positive in achieving all four objectives and that particularly, a specific focus must be planned on capitalizing on the large potential market opportunities in B.C., Canada, the U.S.A. and worldwide to build a strong industrial sector focussing on health care products, devices, services and systems.

8. Training

Increasing use of technology in health care delivery places a growing importance on training health care practitioners in these new and emerging technologies. Coordination is required between the developers of technology and the teaching and training institutions in B.C. namely, the universities, colleges and institutes.

9. Initial Implementation Role for the Committee

The committee recognizes the need for a group to continually review progress, provide updates to the health community, implement the recommendations of this report and coordinate with all parties involved with health care research and development. The committee suggests it function in that overall monitoring role representing the various interested groups in the application of science and technology to the health care sector. This role could continue at least through the next phase of detailing these proposals and their launching into actual funded activities.

CONCLUSIONS

The committee feels strongly that due to the large costs (over $4 Billion a year) and the large area of employment (75,000 people) in the health care sector and the growing demands being placed upon it, science and technology can play a role in economic development, perhaps in containing costs and continuing to provide the excellent health care service currently offered. However, a focus is required on the applied aspects of health care research and a coordinated approach is required between all of those involved in this province, both provincial and national namely, B.C. Health Care Research Foundation, Science Council of B.C., provincial government, the hospitals, the universities, NRC and the Medical Research Council to properly focus on the opportunities available.

APPENDIX A

FUNDING SOURCES FOR HEALTH CARE RESEARCH IN BRITISH COLUMBIA (1986-87)

FUNDING SOURCES FOR HEALTH CARE RESEARCH IN BRITISH COLUMBIA (1986-87)

Funding Source	Amount	% of Total
Medical Research Council	13,449,118	41.1
B.C. Health Care Research Foundation	3,902,753	11.9
National Cancer Institute	2,636,041	8.0
Heart Foundation	1,999,462	6.1
Health & Welfare Canada	1,852,936	5.7
Canadian Companies	1,648,038	5.0
Miscellaneous Foundations and Associations	1,125,229	3.4
Workers Compensation Board	866,417	2.6
U.S. National Institutes of Health	823,451	2.5
U.S. Companies	673,963	2.0
B.C. Medical Services Foundation	563,529	1.7
U.S. Foundations	455,787	1.4
Mr. & Mrs. P.A. Woodward's Foundation	356,954	1.1
B.C. Lung Association	354,117	1.1
Multiple Sclerosis Society	313,377	1.0
Arthritis Society	289,016	0.9
Canadian Cystic Fibrosis Foundation	265,574	0.8
Ministry of Health, Province of British Columbia	226,009	0.7
UBC Research Development Endowment	195,000	0.6
Private Donations	181,860	0.6
Kidney Foundation	171,451	0.5
Miscellaneous Federal Sources	153,323	0.5
Miscellaneous British Columbia Sources	129,713	0.4
Miscellaneous Others	124,744	0.4
	32,757,862	100.00%

APPENDIX B

B.C. HEALTH CARE RESEARCH FOUNDATION - AN INTRODUCTION

B.C. HEALTH CARE RESEARCH FOUNDATION - AN INTRODUCTION

1) History

The B.C. Health Care Research Foundation was established as a non-profit society under the Societies Act of B.C. in 1977 to act as an agency for the allocation of lottery fund proceeds to medical research in the province. At the same time, the Foundation took over the funding activities of both the B.C. Medical Centre and the B.C. Medical Research Foundation which had been disbanded.

The first awards were made in the Fall of 1978 and three research grant competitions were held in both 1979 and 1980. In 1981 the number of competitions was reduced to a more manageable 2 per year, with deadlines in the Spring and Fall.

The funding allocation from the Lottery Fund remained at $2.7 million during the period 1978-83, and has since been increased to the present $4 million.

2) Structure

President and Vice-President of the B.C.HCRF Board of Directors are the B.C. Minister of Health and Provincial Secretary, respectively. Current members of the Board are as listed in Appendix 1. This group has final authority in the awarding of grants and the establishment of policy guidelines for the Foundation. This Board receives advice on grants, procedures and priorities from a Scientific Advisory Committee made up of both medical research scientists and lay representatives [Appendix 2]. The detailed review of grant applications is carried out by 4 special evaluation sub-committees in the fields of clinical, health service, basic medical science studies, and scholarships and fellowships. These sub-committees carry out a peer review, calling on external reviewers (from outside of B.C.) to assist in preparing their recommendations.

The administrative support for these procedures is provided by the Research Secretariat of B.C. (which also serves the Science Council of B.C.)

... 2

3) Priorities

The purpose of the B.C.HCRF, as outlined in its constitution is: "To assist and and collaborate with organizations conducting research in the field of health care in the province of B.C. and without limiting the generality of the foregoing to assist:

(i) basic research

(ii) clinical research

(iii) applied research in the said field of health care."

Since the establishment of the Foundation this policy has been refined somewhat and the Board has indicated that the fields of community health care delivery and clinical studies should receive priority. The Foundation also endeavours to encourage newly-established investigators, where this is practical.

It has been clearly stated that the Foundation should not be considered as an alternative to the MRC in the funding of basic research studies.

4) Awards [see Brochure]

(i) Research Operating Grants

The bulk of support is provided in the form of research operating grants. These are made to individuals or groups for specific research projects. Grants are for one year only, but can be renewed on reapplication for a second year.

... 3

(ii) Research Scholar Awards

A limited number of awards are made to provide support for highly qualified candidates who are starting a career in independent medical research. These may be held for a maximum of four years and are comparable in value and conditions to the MRC Scholar Award.

(iii) Development and Training Fellowships

This category was initiated to provide support for workers in the health care delivery sector who wish to obtain additional qualifications or specialized research training. The value of the award is decided on an individual basis and can be held for a maximum of three years.

Total support provided in all categories has been $33.5 million in 22 competitions over the past 10 years.

5) Additional Information can be obtained from:

B.C. HEALTH CARE RESEARCH FOUNDATION
Research Secretariat of B.C.
100 - 3700 Gilmore Way
Burnaby, B.C.
V5G 4M1

(604) 438-2752

March 1988

Introduction, Appendix 1

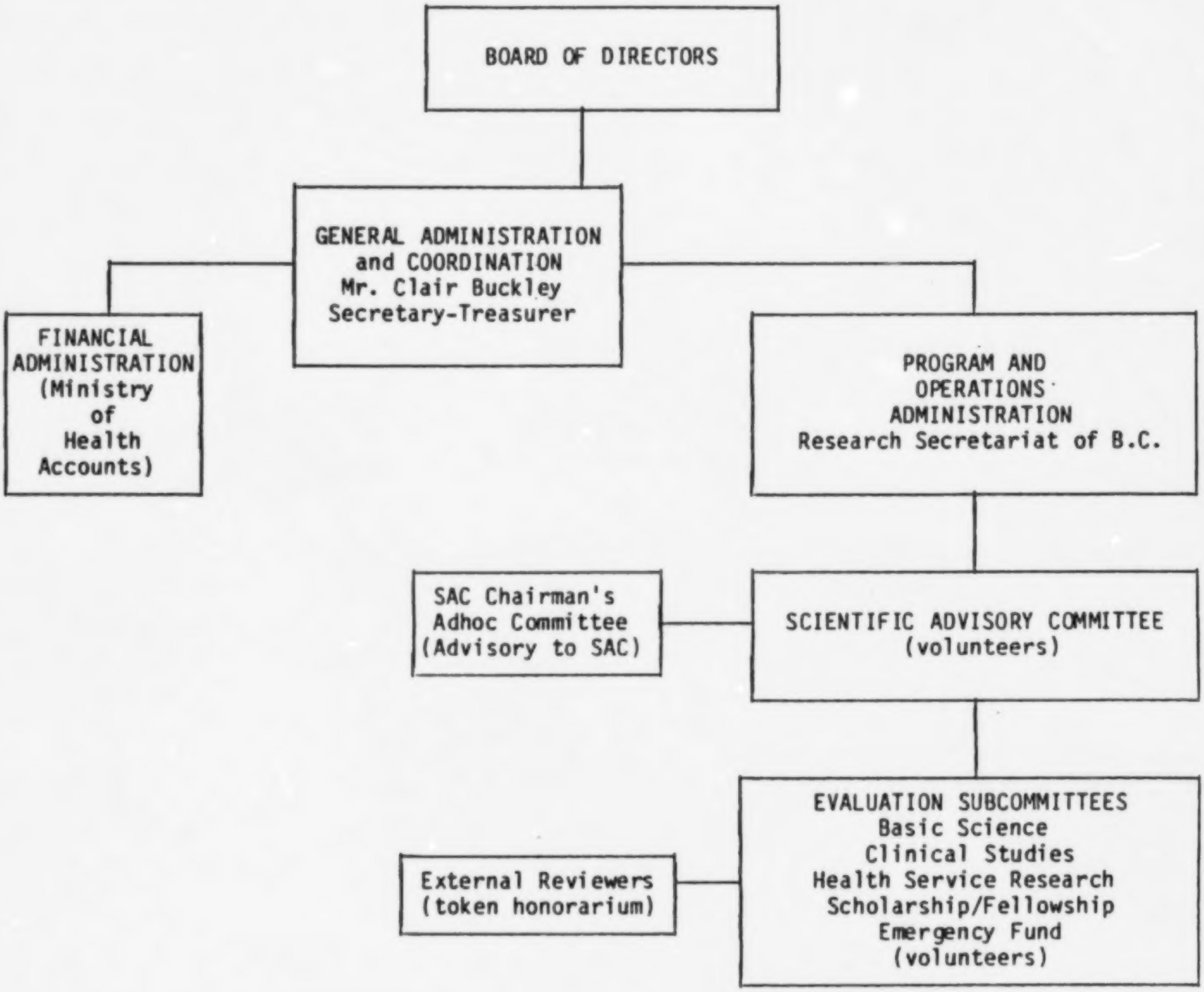
BRITISH COLUMBIA HEALTH CARE RESEARCH FOUNDATION

BOARD OF DIRECTORS

MEMBERSHIP

1. PRESIDENT
   Honourable Peter A. Dueck, Minister of Health
2. VICE PRESIDENT
   Honourable Elwood Veitch, Provincial Secretary and Minister of Government Services
3. Honourable Stanley Hagen, Minister of Advanced Education and Job Training
4. Mr. Douglas Mowat, MLA, Vancouver/Little Mountain
5. Mr. Stanley P. Dubas, Deputy Minister, Health
6. Mrs. Isabel Kelly, Deputy Minister, Advanced Education and Job Training
7. Mr. Melvin H. Smith, Deputy Minister, Provincial Secretary and Deputy Minister, Government Services
8. Mr. C.A. Buckley, Secretary-Treasurer, BCHCRF
   Ministry of Health

BCHCRF ORGANIZATIONAL CHART



BOARD OF DIRECTORS

GENERAL ADMINISTRATION
and COORDINATION
Mr. Clair Buckley
Secretary-Treasurer

FINANCIAL
ADMINISTRATION
(Ministry
of
Health
Accounts)

PROGRAM AND
OPERATIONS
ADMINISTRATION
Research Secretariat of B.C.

SAC Chairman's
Adhoc Committee
(Advisory to SAC)

SCIENTIFIC ADVISORY COMMITTEE
(volunteers)

External Reviewers
(token honorarium)

EVALUATION SUBCOMMITTEES
Basic Science
Clinical Studies
Health Service Research
Scholarship/Fellowship
Emergency Fund
(volunteers)

B.C. LOTTERY FUNDS RECEIVED BY B.C.H.C.R.F.

1978 - $ 2.7 million
1979 - $ 2.7 million
1980 - $ 2.7 million
1981 - $ 2.7 million
1982 - $ 2.7 million
1983 - $ 2.9 million
1984 - $ 3.0 million
1985 - $ 3.4 million
1986 - $ 3.5 million
1987 - $ 4.0 million

Total - $30.3 million

Through interest received during high interest years, and through the generation of a small amount of private funding, the Foundation has been able to distribute $2.65 million more than this.

BCHCRF ADMINISTRATIVE COSTS
(approximations only - per annum)

Salaries	$ 90,000
Rent	$ 10,800
Other	$ 32,400
Honoraria	$ 54,200
	$187,400

DISTRIBUTION OF AWARDS (1987)

Subcommittee	Renewals		New & ReApps		Total		%
	# of Apps	$ Rec.	# of Apps	$ Rec.	# of Apps	$ Rec.	by $ Rec.
Basic Science	23	496,900	35	813,200	58	1,310,100	33
Clinical	18	455,850	39	1,112,850	57	1,568,700	40
Health Service	7	117,105	17	455,757	24	572,862	14
Fellowship	4	94,205	3	48,468	7	142,673	4
Scholarship	6	241,260	3	128,640	9	369,900	9
	58	1,405,320 (35%)	97	2,558,915 (65%)	155	3,964,235 (100.00)	100

5 YEAR PLAN PROPOSAL, 1987 - 1992

5 YEAR SYNOPSIS
Shortfalls, New and Expanded Programs per annum

SHORTFALLS	$2,390,000
EXPANDING RESEARCH AREAS	$1,400,000
HEALTH SERVICE RESEARCH	$800,000
RESEARCH SCHOLARSHIPS	$400,000
MAJOR EQUIPMENT	$750,000
LARGE PROJECTS	$300,000
TOTAL PROPOSED INCREASE	$6,040,000
BASE ANNUAL SUPPORT (1986-1987)	$3,500,000
TOTAL ANNUAL SUPPORT (1991-92 TARGET)	$9,540,000

Note: All amounts are indicated in 1987 dollars with no allowance for inflationary increases

EXAMPLES OF BENEFITS TO COMMERCIAL ENDEAVOURS

1. The physiology laboratory of Dr. John Brown discovered gastrointestinal peptides that control digestion; these peptides are now manufactured (monoclonal antibodies) by his laboratory, "Quadra Logic Technologies Inc." and are distributed and sold as reagents to other research laboratories. This is an example of B.C.H.C.R.F. funded research leading to a successful commercial venture.

2. The automatic tourniquet has been developed by Dr. James McEwen and Dr. Robert McGraw to control blood flow during complicated surgery. This protects tissues by providing sufficient oxygen during lengthy bouts of surgery while also preventing excessive blood loss. Some 400 of these units are now used throughout the world, another commercial success.

PRESENT DIFFICULTIES OF THE B.C.H.C.R.F.

1. Only half of current requests can be funded because of the limited dollars available. This means that annually about 150 health scientists each spend one to four weeks preparing proposals which will NOT be funded. At least 75 of these 150 proposals, or $2 million worth, have sufficient scientific merit to be recommended for funding.

2. Only SMALL projects are funded by the B.C.H.C.R.F.; the administration tries to spread the available funds as widely as possible. The average funding level is $23,000, whereas some projects can require $100,000 - $200,000 per year. At present large projects can only be funded in British Columbia by national or international agencies.

3. The highly competitive nature of current competitions discourages submissions for worthwhile research from less experienced investigators. Occasionally local scientists express understandable frustration with the B.C.H.C.R.F. when their projects cannot be funded. Development grants have recently been offered in the health service area to encourage research by applied health care workers.

4. Doubtless some funded projects will be unsuccessful. Science is by its nature unpredictable, and investigators with the best of knowledge and intentions can move (briefly) into unfruitful areas. A formal evaluation might address this problem and increase efficiency in project selection. (But the amount saved might well be less than the cost of such a difficult formal evaluation.)

5. The B.C.H.C.R.F. is not well-publicized. A major public relations exercise, such as a ten-year birthday celebration/reception (late 1987), in the presence of prominent politicians and white-coated research scientists, covered by TV, radio, and the press, might result in greater public awareness of the benefits gained from B.C.H.C.R.F. funding. General Information Services (G.I.S.) might sponsor this; or a public relations firm might be contracted.

6. British Columbia has not considered tax incentive systems for the support of health research, nor has it examined incentives to encourage entrepreneurial efforts in the area of health technology research. The "Man in Motion" campaign of Rick Hansen might be tapped for research dollars for rehabilitation projects; the Terry Fox/Steve Fonyo money for cancer projects; such other means of enlarging the health research funding base should be carefully explored.

APPENDIX C

BROCHURE - MEDICAL DEVICES CANADA

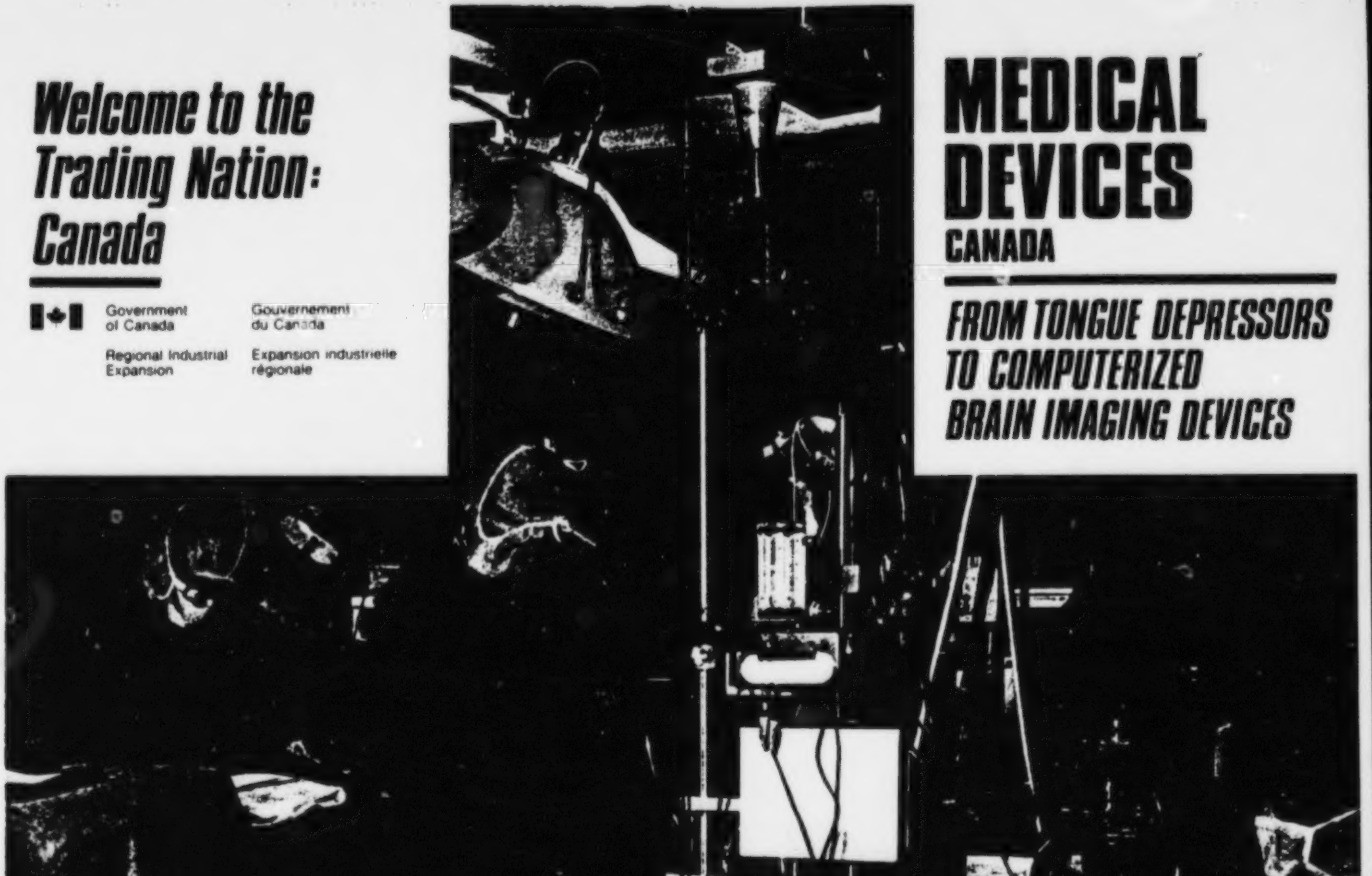
FROM TONGUE DEPRESSORS TO COMPUTERIZED BRAIN IMAGING DEVICES

Welcome to the Trading Nation: Canada

Government of Canada | Gouvernement du Canada
Regional Industrial Expansion | Expansion industrielle régionale

MEDICAL DEVICES
CANADA

FROM TONGUE DEPRESSORS TO COMPUTERIZED BRAIN IMAGING DEVICES



Canada

Investing in
Canada's Medical Device Industry

This brochure provides information on business and investment opportunities in Canada's medical device industry. It also indicates where to get further information and advice from Canadian government departments and agencies, including:

- information on **benefits** of investing in Canada, and the **procedures** involved
- business and investment opportunities in **specific provinces and regions**, and in **other industry sectors**
- **more detailed data** on the medical device industry

Now is an excellent time to invest and do business in Canada's medical device industry:

Canada boasts a highly-diversified and burgeoning medical device industry which enjoys a strong domestic demand combined with ready access to large US and worldwide markets. With a healthy mixture of large multinational firms and smaller, typically more specialized Canadian-owned firms, the industry has ample room for expansion of production capacity for Canadian markets and export. With a long history of product innovations in the field and a well established supporting infrastructure, Canada is an excellent location for development, manufacture and marketing of innovative products.

With favourable provisions for tax treatment of research and development expenditures, a positive attitude toward new investment and a solid community of dedicated scientists, engineers and technologists, Canada is a superb place to establish a wide range of medical device manufacturing facilities.

Publié également en français

MEDICAL DEVICE INDUSTRY

Since Frederic Banting and Charles Best discovered insulin in 1922, Canadians have been at the forefront of medical research.

Over the years, Canadians have played major pioneering roles in the development of life saving technologies, such as the cardiac pacemaker and cobalt cancer treatment unit, as well as other widely used technologies, including the electron microscope, blood vessel stapler, spinal pacemaker (used to stimulate growth in children with spinal deformities), surgical use of lasers and non-invasive diagnostic equipment.

Canada's highly sophisticated and diverse medical manufacturing sector boasts more than 1 200 distinct product lines, including materials, equipment and related components used to diagnose, monitor, treat and assist ill or disabled persons — Canada's medical devices industry covers all key areas:

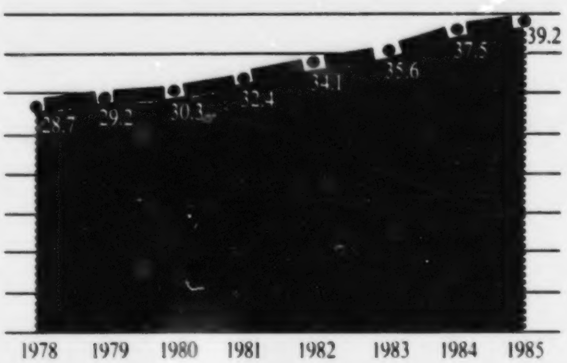
- Medical and dental instruments, equipment, parts and supplies
- Ophthalmic goods
- Surgical and medical supplies
- Hearing aids and orthopaedic appliances, and related parts
- Specialized medical and dental furniture and accessories
- Diagnostic equipment, materials and kits
- Hospital equipment

Products range from tongue depressors and bandages to radiation therapy equipment and computerized brain imaging devices. Innovative products using new materials (e.g. bioceramics) and advanced technologies (e.g. robotics) are being developed and introduced into the marketplace.

Domestic Market: $CDN 1.8 Billion

■ With a population of more than 25 million, and annual public and private expenditures on health alone of $39.2 billion in 1985, Canada constitutes an impressive market for medical devices. In the period 1978 to 1985, Canadian expenditures on health increased 37% in real terms — that's an average of **more than 5% per year**, after adjustment for inflation.

Total National Health Expenditures
public and private
($ billions, constant 1985)



■ In 1986, the total Canadian domestic market for medical devices was estimated to be about $1.8 billion. The Canadian market has grown from $460 million in 1975, which represents a real growth rate in excess of 9% per year.

■ Ninety percent of the total purchases of medical devices in Canada (excluding ophthalmic and dental goods) are accounted for by the 1 200 hospitals operating in Canada.

■ Since more than three-quarters of Canada's domestic demand for medical devices is satisfied through imports, there is considerable scope for expansion or diversification of existing Canadian-based manufacturers or establishment of new enterprises to meet growing demand.

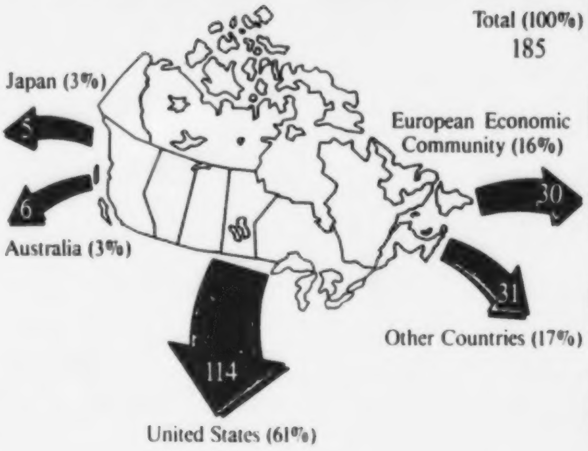
Canadian Imports of Medical Devices, 1986 ($ thousands)

Medical and Related Instruments & Equipment	**686 609**
■ Physiological monitoring & recording equipment, systems, accessories & parts	82 784
■ Electro-medical and electro-surgical apparatus & parts	49 607
■ Surgical instruments of steel, accessories & parts	60 964
■ Medical diagnostic instruments	81 584
■ Dental instruments, equipment, accessories & parts	45 979
■ Ophthalmic equipment, apparatus, accessories & parts	7 572
■ Physiotherapy and veterinary instruments, equipment & parts	8 000
■ Sterilizers, autoclaves & parts (except industrial)	16 016
■ Anaesthetic, and oxygen administering equipment, accessories & parts	47 517
■ Medical and hospital equipment & parts	79 067
■ X-ray film	47 495
■ Other	160 024
Ophthalmic Goods	**160 792**
■ Spectacle and eyeglass frames	64 741
■ Sunglasses, complete with lenses	26 465
■ Spectacles and eyeglasses complete with lenses	1 751
■ Parts for spectacle and eyeglass frames	8 812
■ Other	59 023
Surgical and Medical Supplies	**412 174**
■ Blood handling, analyzing, collecting & processing supplies	24 151
■ Urinary and ostomy appliances, supplies and parts	15 954
■ Catheters, bougies, drains and sondes	23 345
■ Hospital supplies of chemical origin	88 003
■ Surgical implants	70 588
■ Disposable syringes, syringe needles & parts	37 641
■ Disposable medical & surgical instruments and kits	35 573
■ Medical, surgical and hospital supplies	85 970
■ Other	30 949
Hearing Aids and Parts	**17 323**
Orthopaedic Appliances	**34 770**
■ Artificial limbs (prosthetic) & parts	3 016
■ Orthopaedic appliances & parts	10 848
■ Other	20 906
Dental Supplies	**47 070**
■ Artificial teeth, dentures & parts	8 932
■ Dental supplies	38 138
Total Imports	**1 358 738**

- Location in Canada provides **ready access to large markets in the United States.** In 1986, the US market for medical and dental equipment and supplies (including X-ray and electromedical equipment, surgical and medical instruments, surgical appliances and supplies, and dental equipment and supplies) was C $24 870 million. With more than one-tenth of US domestic demand coming from foreign suppliers, US imports amounted to approximately C $2 920 million in 1986.

- More than one-half of Canada's exports of medical devices are shipped to US markets, while overseas markets account for a great majority of the balance of Canada's total exports of medical devices:

Exports of Medical Devices, 1986 $ millions

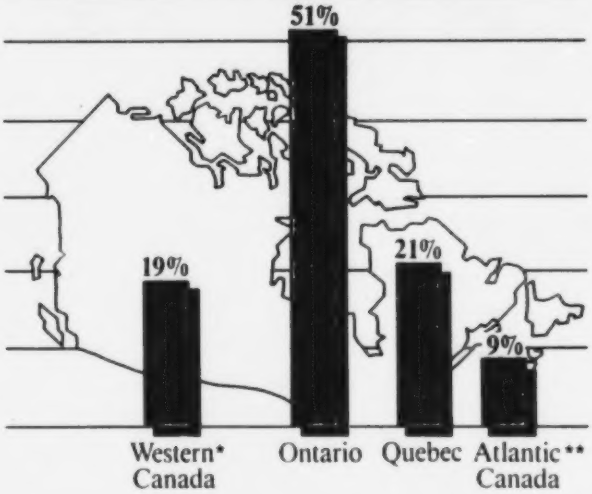


Over 400 Firms Across Canada

■ With more than 400 active manufacturers, Canada's medical device industry employs about 10 000 persons, and accounts for shipments of approximately $600 million annually.

■ Ontario accounts for slightly more than one-half of the industry shipments, and other regions combined account for shipments of approximately $295 million annually.

Distribution of Shipments in Domestic Medical Device Industry, 1981-83 (Average)



* **British Columbia**
Alberta
Saskatchewan
Manitoba

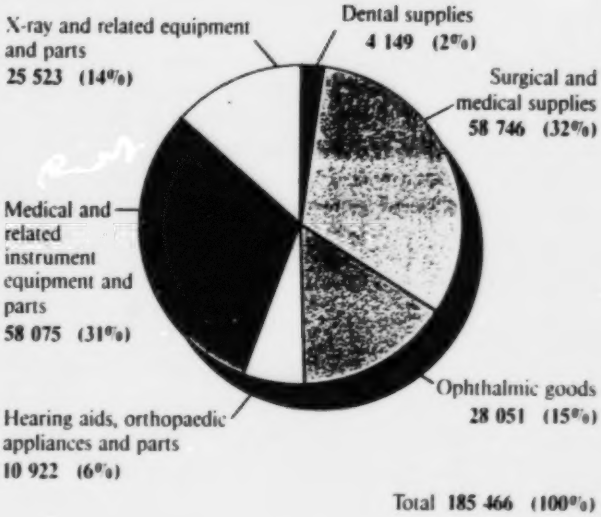
** **New Brunswick**
Nova Scotia
Prince Edward Island
Newfoundland

■ Many of the world's leading manufacturers of medical devices have established major plants in Canada including, for example, the Johnson & Johnson family of companies, Baxter Corp., Picker International Canada Inc., 3M Canada Inc., Smith & Nephew Inc., Becton Dickinson Canada Inc., Medtronic of Canada Inc. and Everest & Jennings Canadian Ltd.

■ While the major international firms are well-represented in Canada, most manufacturers are small to medium-sized Canadian-owned firms. Many are highly specialized, yet flexible. Approximately 80% of all companies employ fewer than 50 persons, while only 10% have more than 100 employees.

■ Canada's domestic manufacturers are heavily **export-oriented,** with almost one-third of total Canadian production destined for foreign markets:

Exports of Medical Devices, 1986
($ thousands)



At The Leading Edge

■ **Smith and Nephew Inc.** operates four large manufacturing plants and an R&D laboratory in Canada. Recent initiatives include a multi-million dollar project to establish a new facility, incorporating the latest state-of-the-art technology to manufacture a complete line of latex medical gloves for domestic and world markets.

■ The **Johnson & Johnson** family of companies, which includes **Critikon Canada Ltd., Ethicon Sutures Ltd., Ortho Diagnostic Systems Inc., Surgikos Canada Inc.** and **Odonto Corporations Ltd.,** is the largest manufacturer of health care products in the world. This group operates eight medical device manufacturing facilities as well as a major research and development centre in Canada. Johnson & Johnson Inc. is currently undertaking a major investment project to produce a new absorbent material which will be used in the manufacture of health care products.

■ **Picker International Canada Inc.** is a major international designer, manufacturer and exporter of diagnostic imaging tools, including CAT-scanners and standard X-ray machines and components.

■ **Beavers Dental Products Ltd.** ranks among the world's largest manufacturers of dental burrs. Its research and development capabilities in Canada keep it at the leading edge of dental instrument technology.

■ **Becton Dickinson Canada Inc.,** which manufactures a variety of medical devices in Canada, is currently undergoing a major plant expansion to increase the production of medical examination gloves for international markets.

■ **Everest & Jennings Canadian Ltd.** is a leading manufacturer of wheelchairs and other related rehabilitation products. The company, which operates manufacturing plants in Ontario and Quebec, recently developed an innovative therapeutic bathing system for geriatric patients.

■ **Andronic Devices Limited** of Vancouver, B.C. has developed a robotic device which holds limbs in position during arthroscopic examinations or surgery. The limbs can be moved into position by voice commands. It is likely that the robotic technology being developed will soon be applied to laboratory functions which are repetitive and manually performed.

■ Another Canadian product currently being widely exported is a needleless insulin injector which is manufactured and marketed by **Advanced Medical Technologies Limited** of Charlottetown, P.E.I. The device delivers pre-measured doses of insulin under pressure through a tiny orifice that penetrates the skin. This form of injection is relatively painless compared to hypodermic injections, and has been a welcome relief to diabetic patients.

■ **Atomic Energy of Canada Ltd. (A.E.C.L.)** produces the majority of the world's supply of cobalt 60 (the conventional source of radiation therapy), and the related equipment. In addition, A.E.C.L. is the world's largest supplier of industrial irradiation plants, many of which are used in the sterilization of disposable medical products.

■ **3M Canada Inc.** is a major manufacturer of medical tapes and medical electrodes, with two manufacturing facilities in Canada and a dedicated health care R&D group. The Morden, Manitoba plant also has a product mandate for its proprietary ligament augmentation device which was pioneered in Canada.

■ **Otto Bock Orthopaedic Industry of Canada Ltd.,** located in Winnipeg, Manitoba, is a world leader in the development and production of prosthetic and orthopaedic devices.

■ **Regal Medi-Spa Co. Inc.** of Scarborough, Ontario has developed and is marketing an innovative bathing system for ambulatory, geriatric and chronic care patients. This product features anti-scald safeguards, automatic mixing and blending of soap/shampoo and of disinfectant as needed, and is designed to eliminate the possibility of cross-contamination leading to infections.

- **Medionics International Inc.** has developed an automatic, volumetric cycler for use by continuous ambulatory peritoneal dialysis and intermittent peritoneal dialysis patients which has been widely accepted in the United States and China.

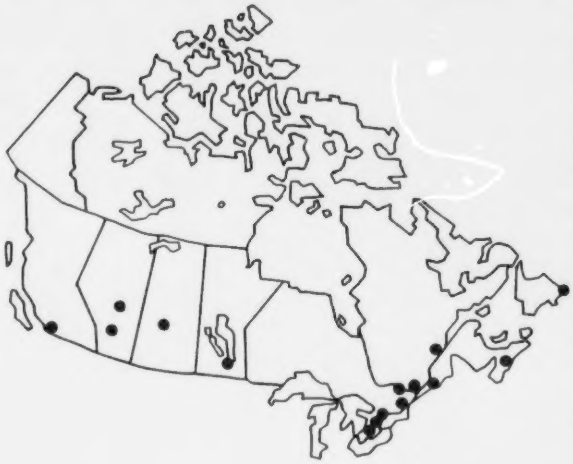
- **Canapharm Inc.** of Saskatchewan, recently established a $4.5 million state-of-the-art facility to produce a range of hospital solutions including intravenous and dialysis solutions. The firm has also announced plans to invest a further $12.5 million to establish a facility at Swift Current, Saskatchewan, to produce medical textiles such as bandages, dressings and tapes.

- **Phoenix Biomedical Products Inc.** of Mississauga, Ontario, is a recognized world leader in the manufacture of petri dishes (over 200 million units annually) and other related products. More than 90% of its annual sales of $7 million are destined for export markets throughout the world.

World-Class Facilities

- There are 16 **world-class medical schools** located in major centres across Canada:

Medical Schools

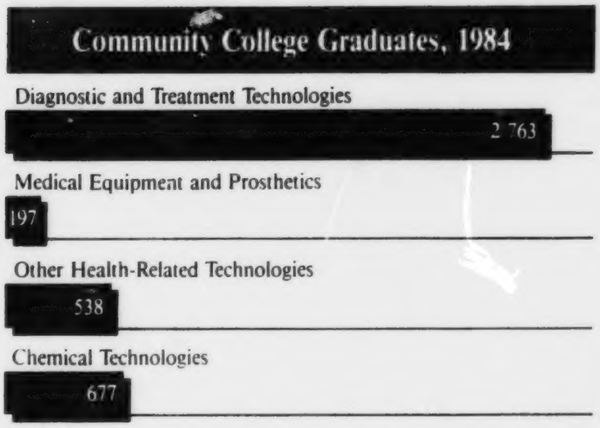


- In addition there are more than 100 active and associate members of the **Association of Canadian Teaching Hospitals**, representing institutions in more than 30 centres across Canada. Canada's teaching hospitals play an important role in the development, testing and promotion of innovations in the medical device industry.

With one of the most comprehensive and sophisticated education systems in the world, Canada provides a steady supply of university and community college graduates with advanced training in all key disciplines essential to the medical device industry:

University Graduates, 1984

Discipline	Bachelor and First Professional Degree	Masters and Doctoral Degrees
Medicine	2 129	459
Pharmacy	654	33
Dentistry	487	21
Nursing	1 746	78
Rehabilitation	857	111
Other Health Professions	135	131
Chemical Engineering	746	188
Electrical Engineering	1 768	371
Mechanical Engineering	1 827	207
Biomedical & Other Engineering	1 529	454
Biochemistry	420	64



Canada's universities provide a focus for innovation in the design and application of medical devices. For example:

The Institute of Biomedical Engineering at the **University of Toronto** has world-class technological capabilities and is particularly renowned for its research expertise in the areas of biomedical acoustics and hearing, ultrasound, biomaterials, prosthetics, imaging, biomedical signal processing and visual field tracking.

The **University of Alberta** is a leader in the research of lasers for medical applications and its affiliated company Chembiomed Inc. has developed advanced blood processing technology.

The **University of British Columbia** has recently received much acclaim for its development work in the areas of robotics for medical applications but it is also noted for its work in other fields including prosthetics and orthotics, equipment for the deaf as well as diagnostic imaging.

Researchers at **McGill University** have achieved notable success in development work in the area of blood perfusion systems and artificial organs.

The **University of Ottawa Heart Institute** is involved in the development of life support systems including artificial organs, cardiac surgery equipment and artificial blood as well as laser applications.

Researchers at the **University of Manitoba** have particular expertise in the development of medical fabrics including surgical sutures and elastics for orthopaedic applications.

Université Laval is leading research in the area of vascular systems such as artificial valves and repair systems as well as oxygenators and life support systems.

Technical University of Nova Scotia in association with **Dalhousie University** has particular expertise in research and development of medical devices relating to the cardiovascular system as well as advanced biomaterials for dental and orthopaedic applications.

The **Bioengineering Institute of the University of New Brunswick** is prominent in the area of myoelectric control systems used in children's prostheses.

- In addition, **l'Université de Montréal,** the **University of Western Ontario,** the **University of Victoria, Queen's University, Simon Fraser University,** the **University of Waterloo** and other prominent universities carry out research essential to the medical device industry.

- Each major university has an office dedicated to assisting the transfer of technology from research laboratories into industry.

- Thirteen institutions provide specialized training in **biomedical engineering** disciplines.

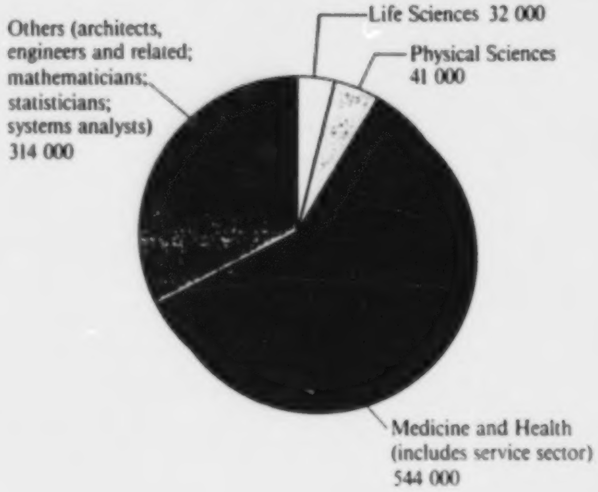
Dedicated To Innovation

- Some $300 million is spent annually in Canada in the area of **health care-related research and development,** thus generating an abundance of intelligence which can contribute to the development of medical devices in Canada.

- In the period 1977 to 1985, total annual in-house industry expenditures for research and development in the **scientific and professional equipment** sector alone increased from $14 million ($s constant 1985) to $37 million. That represents a real increase of 164% over the eight-year period, after adjustment for inflation — **an average growth in R&D of more than 20% per year.**

- With a broad base of more than one-half million technologists, scientists and engineers involved in the various medicine and health-related professions (including health care professionals and support staff in the service sector), Canada has a rich supply of trained technical experts available for design, research, testing and application of medical devices and related products:

Scientists, Engineers and Technologists in the Natural Sciences and Engineering Sector



- In 1984, a total of 9 000 technologists, scientists and engineers in the **medicine and health fields** were **involved in manufacturing industries.** An additional 7 000 personnel in the **life sciences** were directly employed in the manufacturing sector.

- In 1985, the **European Management Forum** ranked Canada **fifth among 20 OECD** nations (ahead of the US, Japan, France, Italy and the United Kingdom) in terms of the rate of growth in the number of R&D personnel in business enterprises.

■ In the period 1978 to 1983, Canada accounted for 5% of the world's potential product inventions for scientific and professional equipment. This was equal to that of West Germany, and only slightly less than that of Japan.

■ A number of government agencies are also charged with the responsibility for supporting R&D activities within government, in the university and in the private sector.

■ The **National Research Council** is a government agency responsible for developing, maintaining, applying and promoting science and technology to meet Canadian needs for economic, regional and social development. Among other things N.R.C. is dedicated to promoting and encouraging expertise in various healthcare fields in Canada and, in this regard, assists industry in undertaking commercially promising research or obtaining the required technology from external sources. The Division of Biological Sciences pioneers research in the life sciences, while the medical engineering unit within the Division of Electrical Engineering conducts exploratory and applied research on equipment related to the biological sciences. The Industry Research Assistance Program which is administered by N.R.C. provides both financial and technical assistance to companies in Canada in their efforts to develop new products and to effect technology transfers from university and government laboratories.

■ The **Medical Research Council** is a government corporation dedicated to the promotion and assistance of basic, applied and clinical research in the health sciences within Canadian universities, and the training and development of research manpower. In the 1985-86 fiscal year, the Council's total expenditures were $157.7 million.

■ The **Natural Sciences and Engineering Research Council** promotes research in the natural sciences and engineering. It also encourages research and development links between universities and industry. Grants totalling $8.8 million were awarded to university researchers in health fields. A further $14.5 million in grants were committed to university research on industrial productivity and development. In addition, grants are available for research, capital expenditures and manpower in a broad range of fields including biotechnology, industrial materials and processes.

■ In addition, most **provincial governments** have placed a high priority on the development of a domestic medical device industry, and in this regard most have institutions dedicated to research in the field.

Supportive of New Investment

- Canada's **tax allowances** for R&D expenditures are more generous than those of the United States. In fact, among all the OECD members plus the five most important "Newly Industrialized Countries" (Brazil, India, Mexico, Singapore and South Korea), Canada ranks third in the tax treatment of R&D.

- In Canada the **R&D tax credit** varies from 20% overall (20% refundable) to 35% for small firms (totally refundable). In addition, the R&D tax credit favours disadvantaged regions. In Atlantic Canada the credit is 30% for large companies (20% refundable).

- Other factors which make Canada's tax treatment of R&D particularly attractive include:
  - Canada's R&D tax credit applies to both the capital and non-capital portion of R&D, whereas in the United States the R&D credit applies only for the non-capital portion of R&D.
  - In Canada the capital portion of R&D is completely written off in the first year.

- For **domestic marketing** of most medical devices, a manufacturer must only submit notification information to Health and Welfare Canada, provided that the manufacturer can demonstrate on request that a device is safe, effective and adequately labelled.

- The Bureau of Radiation and Medical Devices of the Health Protection Branch, Health and Welfare Canada, is the agency which initiates and implements programs designed to ensure that only safe and efficacious medical devices are sold in Canada. In this regard the Bureau's ongoing activities are directed towards investigating health hazards and device deficiencies; providing advice to users, both reactively and proactively; and monitoring and enforcing compliance with the Food and Drugs Act and Medical Devices Regulations.

- Devices which have been designated as new or for which there is a prescribed standard, such as implantables, must undergo a pre-market review before they can be marketed.

- Canada's **Medical Device Regulations** do not require manufacturers to have products approved for sale in the domestic market before they may be exported.

- Canada's procedures for making devices available for **tests and clinical trials** are generally considered reasonable and supportive of rapid product introduction into the marketplace.

- The **Canadian Association of Manufacturers of Medical Devices**, which is the industry spokesperson, is actively promoting and pursuing strategies to encourage the growth and development of the Canadian medical device manufacturing industry.

- In addition, federal and provincial governments in Canada are particularly supportive of new investments in growth sectors such as the medical device industry. While the Ontario and Quebec industrial heartland remains an attractive location for new or expanding medical device manufacturers, increasing attention is being paid to supporting the growth and diversification of the industry in western and eastern regions of the country. For example, both in the Maritimes and in western Canada, several provinces are implementing major initiatives to encourage new investments in the health care products industry.

Diverse Opportunities

■ There are significant investment opportunities for expansion of existing manufacturing capacities in Canada's medical device industry, or establishment of new facilities for research, development, testing and manufacture of medical devices. The opportunities cover all major sectors of the industry:

Medical Instruments & Equipment:

There are a number of opportunities for the expansion of Canadian capacities to manufacture physiological monitoring and recording equipment, electro-medical and electro-surgical equipment and apparatus, diagnostic instrumentation devices, as well as imaging and related equipment. In all these areas, there is growing interest in increasing Canadian production capacity, while taking advantage of existing Canadian technological capacities in the design and manufacture of sophisticated electronic equipment and related instruments. There is a particular demand for medical instruments and equipment which can enhance diagnostic methods and treatment procedures. Some examples of emerging products for which there are potential investment opportunities include:

- Ultrasonic and magnetic resonance imaging devices
- Patient monitoring system
- Non-invasive surgical devices
- Laser equipment for cardiac and other sophisticated forms of surgery
- Artificial organs and implants

Ophthalmic Goods:

There are investment opportunities for the establishment of domestic production capacity for certain ophthalmic goods, including intraocular lenses and plastic ophthalmic lenses for spectacles.

Surgical, Medical and Dental Supplies:

With increasing emphasis being placed upon hygienic and efficient forms of disposable surgical and medical supplies, there are potential investment opportunities for product development and production. Examples include disposable kits and trays for medical and surgical procedures.

Orthopaedic Appliances, Hearing Aids and Self-Care Devices:

With an aging population and almost daily developments in ambulatory aids, prosthetic devices and similar products used to assist the aged, infirm or handicapped, there are new and expanding opportunities for Canadian manufacturers of such devices. Investments are sought in the development and production of various forms of prostheses, orthopaedic devices, incontinence products, as well as products for nursing homes and in-home care.

INVESTMENT OPPORTUNITIES

Diagnostic Equipment, Materials and Kits:

This sector constitutes perhaps one of the fastest growing segments of the health care products market, with growth anticipated to be in the order of approximately 10-20% per annum over the next five years. There are a number of established Canadian companies in this field which are highly receptive to joint venture and technology-transfer opportunities, especially in the biotechnology fields. Opportunities include both test kits and supplies used by hospitals and major health care institutions and clinics, as well as in the growing home or self-diagnostic field.

Computer Hardware and Software:

There are significant opportunities for investment and development of hardware and software for computer-aided medical applications, including:

- Computer facilities and processes for enhancing speed, image, clarity and analytical capabilities of medical imaging equipment and other medical devices
- Computer-aided design and manufacture of prosthetics and surgical implants
- Computer-based medical information systems dealing with financial and administrative records, patient medical histories, pharmacy inventories, and medical service schedules.

GOVERNMENT ASSISTANCE

The **Department of Regional Industrial Expansion** is a department of the Government of Canada devoted to serving needs of Canadian businesses, as well as foreign businesses operating or wishing to invest in Canada. These range from single-person enterprises to large multinationals. The department has more than 30 offices to serve businesses in every province and territory in Canada. In addition, the department works in close cooperation with Investment Canada and the international offices of the Department of External Affairs.

The objectives of Regional Industrial Expansion are to promote and support the productivity, profitability and competitiveness of Canadian businesses in a manner which respects the different business opportunities and conditions in each region of the country.

Regional Industrial Expansion helps businesses to gain access to information, advice and money needed to meet their business and investment objective. Assistance and support is available for businesses at any stage in the business cycle, from setting up operations to expanding or modernizing facilities. In many cases, special support is available for targeted industry sectors and regions of the country in support of Canadian and provincial industrial development strategies.

GOVERNMENT ASSISTANCE

For Further Information, Contact The Nearest Canadian Embassy Or Consulate.

Or:

DEPARTMENT OF REGIONAL INDUSTRIAL EXPANSION
Director
Biotechnology and Health Care Products Directorate
235 Queen St., 9th Floor East (IRPI)
Ottawa, Ontario K1A 0H5
Canada

Tel: (613) 954-3077
Telex: 053-4123 (IRPI)
Facsimile: (613) 954-1894

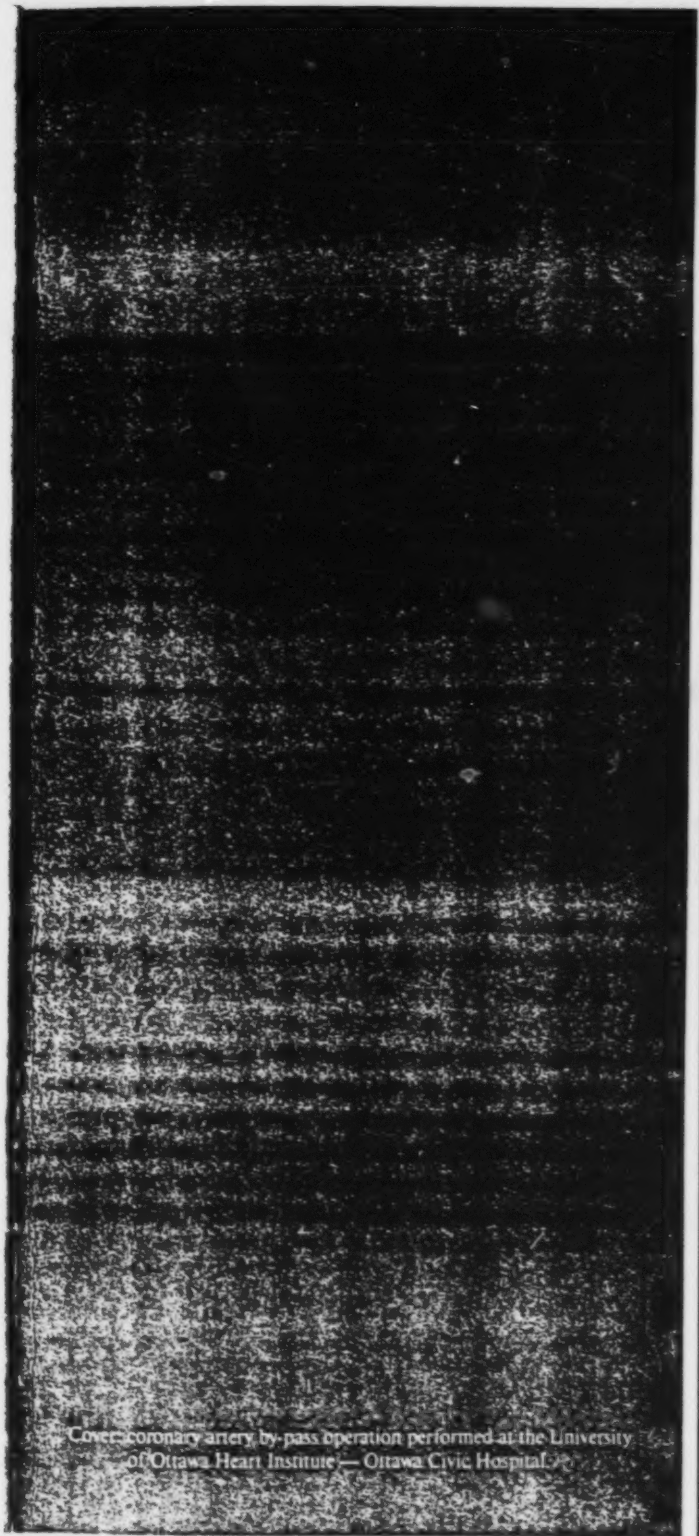
INVESTMENT CANADA
Director
Investment Services
235 Queen Street, 5th Floor West
P.O. Box 23800, Station "D"
Ottawa, Ontario K1P 6A5
Canada

Tel: (613) 995-0465
Telex: 053-4450
Facsimile: (613) 996-2515

For Specific Enquiries Relating to Medical Device Regulatory Requirements, Please Contact:

HEALTH AND WELFARE CANADA
Chief
Pre-Market Division
Bureau of Radiation and Medical Devices
775 Brookfield Road
Ottawa, Ontario K1A 1C1
Canada

Tel: (613) 954-6701
Telex: 053-3679
Facsimile: (613) 954-7689



Cover: coronary artery by-pass operation performed at the University of Ottawa Heart Institute — Ottawa Civic Hospital.

APPENDIX D

PROPOSAL FOR A BIOMEDICAL ENGINEERING INITIATIVE AT THE UNIVERSITY OF BRITISH COLUMBIA

RECEIVED
OCT 20 1987
BIOMEDICAL ENGINEERING

August 18, 1987

PROPOSAL FOR A BIOMEDICAL ENGINEERING INITIATIVE AT THE UNIVERSITY OF BRITISH COLUMBIA

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EXECUTIVE SUMMARY

It is proposed to establish a Biomedical Engineering Initiative at UBC, having an initial focus aimed at the need-oriented development of new medical devices and related technology. This activity will strengthen already-existing research at UBC, and will promote the establishment of new interdisciplinary research within the University, particularly between the applied sciences and the health sciences, as well as within the health care services and industrial sectors in B.C. Close collaboration between UBC and its five affiliated teaching hospitals, as well as collaboration with relevant provincial agencies, industry and other institutions, will be emphasized. UBC is the logical centre for this much-needed activity in biomedical engineering because it has the Province's only medical faculty and related health sciences faculties and programs, because a nucleus of pertinent research and development activities already exists, and because an informed network involving UBC, various teaching and research hospitals in the province, and related agencies and industries has already been initiated. The proposed Biomedical Engineering Initiative will require an annual operating budget of approximately $700,000, a capital equipment budget of $225,000, and space of approximately 6,500 NSF. It is anticipated that the knowledge, graduates, interactions, and industrial activity arising from the biomedical engineering activity will have significant educational, economic and social benefits for the people of the Province of British Columbia.

1. INTRODUCTION

The rapid pace of technological advancement in health care has made essential inter-disciplinary cooperation in research and collaboration with the health care system in general, and hospitals in particular.

Significant research expertise already exists at UBC in the area of biomedical engineering, however the activities tend to be diffuse, organized along Departmental lines and not focussed enough. Also the number of faculty involved is too low to assure a reasonably broad covering of the field and achieve significant economic impact.

It is being recommended that the focus of biomedical engineering activities at UBC be on the need-oriented development of new medical devices and related technology. This would be a unique mandate in Canada. There is currently no other organized effort along these lines at any Canadian university, despite the existence of long-standing and innovative research groups in biomedical engineering at the University of New Brunswick, McGill University, and the University of Toronto.

2. RESEARCH FOCUS

The proposed strategy is is to emphasize one area of biomedical engineering, and to use that as an engine to drive related spin-off activities and research. A unique focus for biomedical engineering in British Columbia would be the development of new medical devices and related technology to meet urgent and unmet needs of the health care system. In this context "medical devices" are broadly defined as tools or machines designed for specific diagnostic or therapeutic functions, and the definition is meant to include transducers and instrumentation, electrical and mechanical hardware, related software and biomaterials.

The general goal in developing such medical devices and related technology would be: (1) to improve the quality of diagnosis and treatment; (2) to control or reduce the costs of such diagnosis and treatment; and (3) to reduce the exposure of patients and staff to hazards.

The Biomedical Engineering Initiative would establish capabilities for research, development, design, system integration and manufacture, and for providing services in both the public and private sectors. The public sector needs biomedical engineering expertise for hospitals, federal and provincial governments, and universities and post-secondary institutions. The private sector currently requires biomedical engineering expertise in order to establish a viable medical device industry in Canada. Excellent opportunities also appear to exist for adapting the expensive medical technologies that are now widely used in North America for appropriate less costly use in developing countries, thereby creating major export opportunities for Canadian manufacturers.

A detailed summary of the nature and magnitude of the needs and opportunities related to the development of medical devices and related technology is given in Appendix I. With regard to the economic implications, the Department of Regional Industrial Expansion (DRIE) has recently completed an evaluation of the health industry in Canada, and has in particular studied opportunities for health industry development in western Canada. DRIE has estimated that approximately $40-billion are spent annually in Canada on health care, of which $2-billion are spent on medical devices in Canada. Of this total, 80% (or $1.6-billion) of the expenditures for medical devices are for imported products. Considering western Canada as an economic entity, $12-billion are spent on medical devices. In British Columbia, a total of $4.7 billion is spent annually on health care, of which an estimated $236-million is spent on medical devices. In British Columbia, the DRIE study has indicated that there is a major disparity between the expenditures on medical devices and the location of medical device industries. This is best illustrated by Figure 1, which shows that western provinces account for 31% of the expenditures for health care in Canada, but only 13% of Canadian health care industries are located in western Canada. Clearly, a need and an opportunity exists to develop a health care products industry in British Columbia, for the purpose of economic growth and industrial diversification. The establishment of a Biomedical Engineering Initiative at UBC should be a key element of such a strategy.

3. EXISTING STRENGTHS

There are activities in biomedical engineering presently being carried out within the departments of Electrical Engineering, Mechanical Engineering, Metallurgical Engineering, Physics, Engineering Physics, Chemical Engineering and the Faculty of Dentistry at UBC. Some undergraduate and graduate courses offered cover topics relevant to the biomedical engineering field. The list of courses offered and faculty members involved is given in Appendix II.

Significant resources are available in the hospitals. For example, the annual operating budget of the Vancouver General Hospital is over $170-million. The annual operating budget of

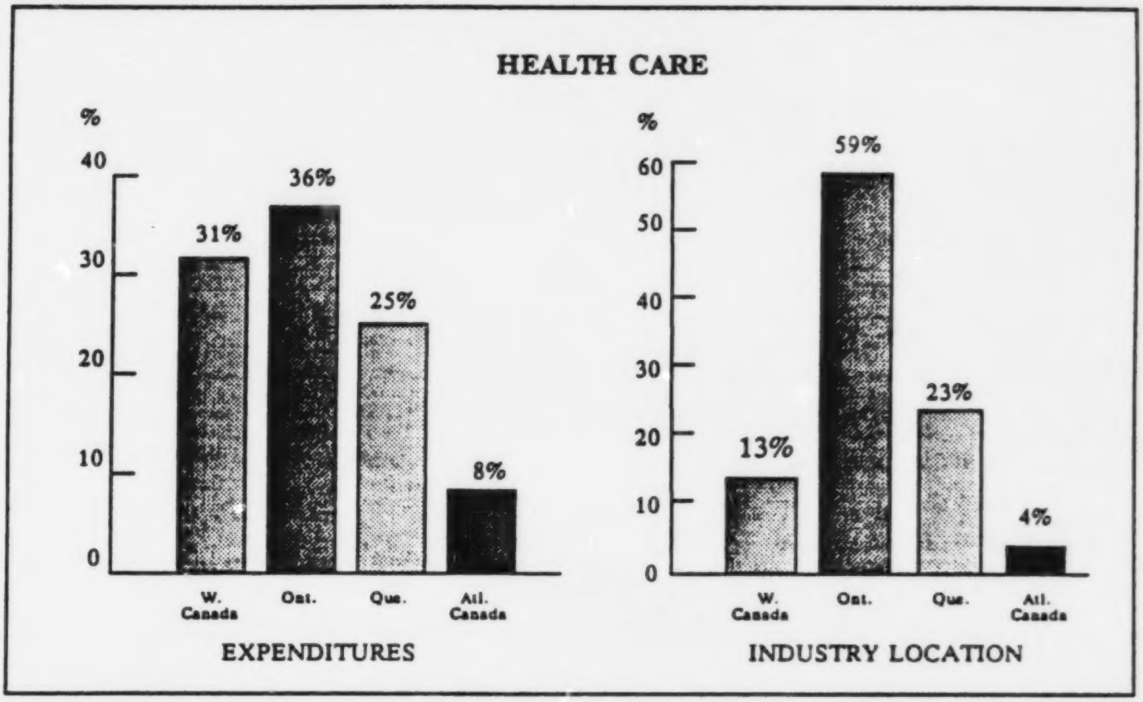

Figure 1: Health care expenditures versus industry location in Canada (from DRIE)

the UBC Health Sciences Centre Hospital is more than $40-million. Such hospitals allocate approximately 5 percent of their operating budgets for capital medical technology (not including disposable devices, accessories and supplies), and have annual capital budgets for major new technology equal to an additional 2% of their operating budgets. The resulting accumulation of medical technology is considerable: at these two hospitals alone, the replacement cost of capital medical technology is well over $25-million. Both hospitals are already affiliated with UBC, as are three other teaching hospitals and additional institutions such as the G.F. Strong Rehabilitation Centre.

Vancouver has:

- the best infrastructure of hospital-based biomedical engineering departments in Canada for the identification of opportunities for the need-oriented development of new medical technology, and for the evaluation of such technology as it is being developed;

- convenient access to a wide range of tertiary and quaternary facilities for diagnosis and treatment;

- a recent track record and history of success in specific areas of medical-device development which is second to none in Canada; and

- a high level of interest on the part of talented and academically first-class undergraduate and graduate students in engineering who are keen to become involved in such an initiative.

While some may point to the lack of an established medical device manufacturing industry in British Columbia, the fact there is a very large "hidden" health services industry having annual expenditures between $3.3 and $4.7-billion dollars in B.C., which could serve as the base from which to support the proposed initiative for the need-oriented development of new technology.

4. SUPPORT FROM INDUSTRY

Support from industry for biomedical engineering can be grouped into the following general categories:

- B.C. companies and organizations now involved in the manufacture, development and marketing of medical devices and related health care products (see Appendix III for a list of 25 companies known to UBC);

- companies and organizations in British Columbia which are presently not involved, but which could become involved in the development, manufacture and marketing of medical devices and related systems and products (see Appendix IV for a list of 30 companies known to UBC);

- multinational health care companies wishing to hire qualified engineering staff or wishing to identify a world product mandate suitable for British Columbia; and

- the health service industry in British Columbia, i.e. hospitals, rehabilitation centres and health care delivery organizations (see Appendix V for a list of centres and organizations which have already expressed interest).

5. DEVELOPMENT PLAN AND RESOURCE REQUIREMENTS

In order to start a concentrated effort in the area of biomedical engineering it is necessary to coordinate existing activities in this field, as well as to assure their focus and breadth. The following resources will be required.

5.1 Staff

A senior academic expert in the field of biomedical engineering, experienced in the development of medical devices, should be appointed to act as coordinator of the program. Four new appointments (2 in Electrical Engineering and 2 in Mechanical Engineering) at the assistant or associate professor level are required in order to assure an appropriate breadth of graduate teaching and supervision of graduate students, in M.A.Sc. and in Ph.D. programs. Two to three research associates in the health sciences will also be required and it is anticipated that appointments to these positions will be made for terms of one or two years. Also, three research engineers or research associates are required in Electrical and Mechanical Engineering. Support staff composed of two biomedical technologists (one in Electrical Engineering and one in Mechanical Engineering) and one secretary will also be needed.

The senior academic coordinator and the research associates in Health Sciences might be joint appointments between the Faculty of Applied Science and the Faculty of Medicine. The other seven appointments would most likely be in Electrical Engineering and Mechanical Engineering. The budget for the staff required above is estimated as follows.

Position	No.	Salary($)	Total($)
Senior Academic Coordinator	1	75,000	75,000
Assistant/Assoc.Professors (2 in Electrical Engg., 2 in Mechanical Engg.)	4	45,000	180,000
Health Research Associates (in Health Sciences Dept.)	2–3		150,000
Engineering Research Assoc. (in Electrical Engg. and Mechanical Engg.)	3	40,000	120,000
Biomedical Technologists (1 in Electrical Engg., 1 in Mechanical Engg.)	2	32,000	64,000
Secretary/Receptionist	1	20,000	20,000
		TOTAL:	$609,000
Benefits @ 15%			91,350
		TOTAL:	$700,350

5.2 Organization

It is proposed that the Biomedical Engineering Initiative be established and coordinated by an advisory committee having approximately equal representation from the applied sciences and health sciences. The suggested composition of the advisory committee is as follows: the Coordinator of the Biomedical Engineering Initiative; the Dean of the Faculty of Applied Science, or his designate; the Dean of the Faculty of Medicine, or his designate; the Coordinator of Health Sciences, or his designate; a faculty member from Electrical Engineering and one from Mechanical Engineering who are active in a relevant area of biomedical engineering; a faculty member from one of the health sciences faculties who is active in a relevant area; the Director of the combined Biomedical Engineering Department of the Vancouver General Hospital and UBC Health Sciences Hospital; the Director of the UBC Clinical Engineering Program; and at least one ex-officio representative of B.C.-based firms engaged in the development and manufacture of medical devices or related technology. It is proposed that the chairman of the advisory committee be chosen from among the health sciences representatives, in order to maintain a balance between the health sciences and the applied sciences.

5.3 Space

A total of 6,500 net sq. ft. of core space is required for the Biomedical Engineering Initiative. It is anticipated that at least an equal amount of additional non-core space will be made available by collaborating hospitals, institutions, agencies and firms. Preferably, the core space will be located at UBC close to existing space of the Faculty of Applied Science. It may be most cost-effective to provide this core space in a new building. Although space close to the existing facilities of the Faculty of Applied Science is preferred, alternate core space might be arranged on an interim basis in conjunction with one or more of the teaching and research hospitals and institutions associated with UBC.

Details of the space requirements are given below.

Function	Unit Size (NSF)	Unit Number	Total (NSF)
Labs - R&D	250	11	2,750
Support - Electronics	500	1	500
- Mechanical	500	1	500
- Computers	500	1	500
Supplies & Components	250	1	250
Offices	150	10	1,500
Secretary/Reception	250	1	250
Seminar/Meeting Room	250	1	250
		TOTAL:	6,500

5.4 Equipment

An equipment budget of approximately $225,000 is required for the Biomedical Engineering Initiative. Of this total, approximately $125,000 will be allocated for instrumentation, electronic apparatus and mechanical apparatus for the development, design and evaluation of prototypes of new medical devices. An additional amount of $100,000 is required for equipping new facilities with microcomputers, automated workstations, accessories and peripheral devices for automated design, real-time data acquisition and analysis, modelling and other functions related to the development and evaluation of new medical devices. It is recognized that the incremental funds being sought for equipment are very modest, but it is anticipated that the collaborating hospitals, institutions and firms will provide sufficient access to additional test equipment, prototype fabrication equipment and related systems and facilities having a minimum replacement cost of over $2-million. In addition to this equipment, teaching hospitals and institutions affiliated with UBC will also provide sufficient access for the Biomedical Initiative to the existing base of medical technology in those hospitals and institutions estimated to have a current replacement cost of more than $25-million.

6. EXPECTED BENEFITS

The primary benefit arising from the Initiative would be the development and availability of need oriented technology which would be of use in British Columbia, as well as elsewhere in Canada and the world, to help control or reduce the costs of diagnosis and treatment, and to help reduce the exposure of patients and staff to unnecessary hazards.

Another benefit from this Initiative would be the availability of well trained engineering graduates suitable for careers in research, development, design, system integration and manufacture, and services in both the public and private sectors. This would include providing individuals with expertise suitable for high-technology research and development, emerging growth companies, new ventures in medical technology, hospitals, federal and provincial governments, regulatory agencies, and universities and post-secondary institutions.

Significant economic benefits can be expected as spin-off activities. Historically, many of the most successful medical device companies in the world today began as a collaboration between a few individuals associated with universities, hospitals and the private sector. Even in recent years, despite the great increase in the sophistication of medical technology and in the vertical integration and consolidation of companies within the health care industry, many exciting and highly successful medical device companies continue to emerge from similar collaborations.

Each such successful venture succeeds in tangibly improving the quality of health care, while at the same time generating satisfying and exciting career opportunities for individuals in engineering and health care disciplines. This helps complete the cycle by which the community, which initially supported the university financially, receives benefits in terms of increased economic activity, increased quality of health care and an increased number and variety of challenging employment opportunities.

In the Vancouver area, there have recently been some clear indications that the same pattern of success, growth and economic activity is achievable here. For example, a microprocessor-based surgical tourniquet which was developed as a result of collaboration between James McEwen, a biomedical engineer, and Robert McGraw, an orthopaedic surgeon, is now in widespread use in more than 25 different countries throughout the world. Every day several thousand of these medical devices, which emerged from a research and development program in B.C., are used to improve the quality and safety of surgical procedures at major teaching and research hospitals in Canada, the United States, Japan and Europe. More recently another collaborative effort between biomedical engineers and individuals in health science faculties at UBC, in conjunction with a B.C. company, Andronic Devices Ltd., has resulted in the development of innovative medical and surgical robotic systems and world recognition that this effort is in the forefront of a new generation of advanced medical devices with significant economic potential. Recently, Andronic Devices began producing the first batches of advanced medical devices resulting from their research and development program, which will be manufactured in B.C. and marketed worldwide by a premier multinational corporation. In different areas, a driving simulator for the evaluation of disabled drivers, developed by Charles Laszlo (UBC) and Cecil Hershler (G.F. Strong Rehabilitation Centre), is about to enter the limited production stage, and the first CAD/CAM system for automated prosthesis design, which was developed and manufactured by Shape Technologies Inc. (a B.C. spinoff company from the UBC Medical Engineering Resource Unit at Shaughnessy Hospital), has been marketed successfully.

The proposed Initiative in Biomedical Engineering will meet not only a provincial need but also a national one as there is no other organized effort along these lines at any Canadian university, despite the existence of long-standing and innovative research groups in biomedical engineering at universities in other provinces.

7. CONCLUSIONS

We recommend that action be taken now to significantly enhance activities in the area of biomedical engineering. The focus of activities should be development of new medical devices and related technology. Research hospitals and existing flourishing biomedical engineering departments at these hospitals in Vancouver, together with thriving engineering and health science faculties on campus are important elements for the success of this initiative.

APPENDIX I

Needs and Opportunities

This appendix provides background information to illustrate the nature and magnitude of the opportunities which could be exploited by a Biomedical Engineering Initiative at UBC.

Some of the information contained in this appendix has been derived from a market study released recently by the Ontario Centre for Microelectronics (CCM) of Ottawa, entitled Microelectronics Opportunities in Health Care. According to the OCM study, Canadians spend more than $30-billion per year on health care, in excess of $1,200 each, but even this large sum is 25% less than the comparable sum now being spent in the U.S. Table 1 summarizes the projected Canadian market for medical devices in 1987.

TABLE 1: 1987 CANADIAN MEDICAL-DEVICE MARKET (PROJECTED)

ITEM	Domestic market ($millions)	Imports Total ($millions)	Imports U.S. ($millions)
Cardiology equipment	41.3	29.5	26.3
Pulmonary equipment	18.1	12.9	11.6
Neurological equipment	7.4	5.3	4.5
Ophthalmological equipment	15.3	11.0	8.7
Pediatric equipment	9.0	6.5	5.2
Operating room equipment	67.2	48.4	39.0
General hospital equipment	150.0	90.0	76.5
Clinical lab equipment	71.7	55.2	49.7
Misc. health care products	3.4	2.4	1.9
Disposables	269.5	161.7	129.4
Orthopaedic and prosthetic	77.6	49.7	42.2
Architectural, transport and mobility	19.8	7.9	7.3
Physical and occupational therapy	16.8	5.0	4.5
Sensory aids	22.3	11.1	8.9
TOTAL:	819.3	518.1	432.6

Health-care expenditures are growing at 1.2% above the annual gross domestic product (GDP) increase in Canada (between 1961 and 1982); the comparable figure in the U.S. is 3%.

In response to rapid escalation in the cost of health-care delivery, both Canadian and U.S. systems are under pressure to contain further cost increases. Health-care systems will undergo a dramatic transformation over the next two decades. Two major changes in patterns of delivery will be an increasing number of freestanding ambulatory-care centres and a growing market for home health-care goods and services.

Freestanding ambulatory-care centres provide specialized outpatient care at a substantially lower cost than acute-care facilities. Hearing, optical, dialysis, surgery, emergency-care and dental centres began appearing in the mid-1970's and have experienced rapid growth.

It is estimated that 30% to 40% of all surgical procedures in the U.S. could be performed on an outpatient basis in freestanding surgery centres.

Home health-care is a relatively new industry that has begun to grow significantly in recent years. One source says the market for home health-care products will reach U.S. $9.4-billion by 1990, up 65%. When nursing, technical and physical therapy services are added, the OCM report projects the total market for home health care at nearly U.S. $16-billion in 1990.

According to another study, the market for home diagnostics products will reach U.S. $875-million by 1990, an increase of 151% over the 1984 level. That report indicates the home diagnostics market in 1984 was segmented as follows:

Heart-related products	40%
Diabetes products	27%
Health-monitoring tests	18%
Disease diagnostics	15%

Many of these home diagnostics devices will use medical technology and microelectronics developed by, or in conjunction with, biomedical engineers. Home-care products already on the market include digital pulse meters and scales, electronic blood-pressure, heart-rate and glucose monitors, electronic thermometers, and transcutaneous electrical nerve stimulation (TENS) units.

Opportunities for the development of new medical technology will also exist in virtually every aspect of health care. New technology, particularly associated with rapid developments in microelectronics technology, will have a revolutionary impact on health care delivery

Numerous opportunities exist for companies based in British Columbia and elsewhere to develop new products which:

(a) represent advances in diagnostic, therapeutic and preventative health-care delivery;

(b) make it possible to deliver an increasing proportion of health care services in ambulatory clinics, private homes and nursing homes;

(c) are non-invasive, inexpensive and easy to use;

(d) do not require significant additional training or additions to medical/technical staff; and

(e) improve the productivity of medical/technical personnel.

Innovation and technological development, largely by biomedical engineers, will continue to serve as the engines of growth in a diversified medical devices industry.

In the past, innovation in health care was directed primarily towards improving the delivery of medicine. In the future there will be increasing emphasis on the development and diffusion of innovations which relocate the delivery of medicine or lower its cost.

The U.S. Department of Commerce reported that the medical electronics sector of the medical device industry in the U.S. consisted of 261 establishments in 1985. Two-thirds of these firms have fewer than 20 employees, providing an indication of the opportunities available to emerging firms with innovative products.

In 1985, the U.S. medical device and medical electronics sector of the medical device industry recorded a balance-of-trade surplus of U.S. $290-million, an increase of 12% over the previous year.

Over the 1976 to 1985 period the total value of shipments of medical devices incorporating electronics increased to U.S. $5.3-billion at an average annual rate of 17%. In 1972, medical electronics accounted for 11.6% of total shipments of medical devices. By 1983 this had increased to 31.6%.

In addition to products that will reduce our reliance on hospitals, there will be a strong demand for products developed by biomedical engineers that will improve the operational efficiency of hospitals. The impact that such new medical technology will have on health-care delivery includes the following.

Faster diagnosis. Using noninvasive techniques, new technology will allow for earlier diagnosis of disease, will increase the probability of early detection through regular monitoring, and will allow a greater number of tests to be performed in the same period.

More accurate diagnosis and therepy. Medical devices that incorporate new technology will increase the volume and quality of information physicians have about individual patients, allowing more accurate diagnosis and case-specific therapies.

Physicians will no longer have to rely on the shotgun approach of using a broad group of general therapeutic procedures designed to treat a number of illnesses.

Deinstitutionalized health-care delivery. Advances in medical telchnology by biomedical engineers will result in the development of smaller, less expensive, smarter, and easier-to-use medical devices. There will be an increase in the proportion of diagnosis and therapy done in alternative settings, including ambulatory-care centres and the home.

Development of less-invasive and noninvasive procedures. These new developments will cut the time required to administer specific diagnoses and therapies, reduce recovery time, and be generally less painful and traumatic. For example, CT scanning has dramatically slashed exploratory surgery for cranial, abdominal and mediastinal diagnoses. Before CT scanning, exploratory surgery was used in 33.9% of such diagnoses. By 1980, this figure was 16.5%.

Opportunities for applications of new technology in health care are very broad. Clearly, new industries based in British Columbia are unlikely to be able to participate on a world scale in every one of these emerging areas. However, there are a number of excellent existing and potential niches that could be identified, strengthened and exploited in British Columbia to establish a centre of excellence for the need-oriented development of new medical devices and related technology in conjunction with emerging and diversifying firms particularly in British

Columbia and elsewhere in Canada, for the world market. This is the strategy and focus of the UBC Biomedical Engineering Initiative.

APPENDIX II

FACULTY INVOLVED IN BIOMEDICAL ENGINEERING RESEARCH

DR. J. L. Bert, Professor	Department of Chemical Engineering
Dr. K. L. Pinder, Professor	Department of Chemical Engineering
Dr. J. R. Grace, Head	Deprtment of Chemical Engineering
Dr. M. P. Beddoes, Professor	Department of Electrical Engineering
Dr. C. A. Laszlo, Director	Department of Clinical Engineering
Professor	Department of Electrical Engineering
Dr. J. McEwen, Adjunct Professor	Department of Electrical Engineering
Dr. P. Lawrence, Professor	Department of Electrical Engineering
Dr. V. J. Modi, Professor	Department of Mechanical Engineering
Dr. L. D. Skarsgard, Professor	Department of Physics
Dr. B. Palcic, Assistant Professor	Department of Physics
Dr. G. Lam, Assistant Professor	Department of Physics
Dr. R. O. Kornelsen, Lecturer	Department of Physics
Dr. R. E. Durand, Honorary Professor	Department of Physics
Dr. P. L. Olive, Associate Professor	Department of Physics
Dr. K. A. Skov, Assistant Professor	Department of Physics
Dr. D. J. Chaplin, Assistant Professor	Department of Physics.

COURSES RELATED TO BIOMEDICAL ENGINEERING

Chemical Engineering

CHML 479 (Dr. J.L. Bert)
Chemical Engineering Aspects of Occupational Health Safety Relationship between current engineering practice and worker health and safety. Engineering analysis of industrial health and safety problems.

CHML 559 (Dr. N. Epstein)
Topics in Chemical Engineering: a discussion of some aspects of modern Chemical Engineering. Subject matter varies each year.

Clinical Engineering

APSC 550 (Dr. C. A. Laszlo)
Biomedical Measurements and Biomaterials: principles and technology of measuring temperature, displacement, motion, force, pressure, flow, ions, dissolved gases and bioelectric potentials in living organisms.

APSC 552 (Dr. C. A. Laszlo)
Clinical Engineering Seminar: Technology utilized in diagnosis, monitoring, therapy and rehabilitation.

APSC 554 (Drs. G. J. Eisler, R. W. Evans, C. Hershler, J. R. Heyworth, G. Klein, C. A. Laszlo, J. A. McEwen, K. D. Whitmore)
Directed Studies in Clinical Engineering: supervised work on several clinical engineering projects in local hospitals.

APSC 556 (Dr. C. A. Laszlo)
Clinical Engineering Practice: principles of management of clinical engineering practice, functions, organization and operation of hospital-based clinical and biomedical engineering departments.

Electrical Engineering

ELEC 473 (Dr. J. A. McEwen)
Systems Laboratory - Selected students undertake the development, design, implementation and evaluation of new or modified medical devices in an acute-care hospital environment.

ELEC 588 (Dr. M. P. Beddoes)
Biomedical Signals and Systems Analysis Modelling and analysis of biological control systems and prostheses.

ELEC 590 (Dr. P. D. Lawrence)
Speech Analysis and Synthesis: analysis and characterization of speech signals.

Mechanical Engineering

MECH 450 (Dr. B. Dunwoody)
Design I: Properties and selection of materials; stress concentration and fatigue; screws, fasteners and joints; mechanical springs; friction and wear. Prerequisite: MECH 341.

MECH 451 (Dr. B. Dunwoody)
Design II: Rolling and hydrodynamic bearings; spur, helical, bevel and worm gears; gear trains; shafts; clutches, brakes and couyplings; circuits; flexible machine elements. Prerequisite: MECH 450.

Metallurgical Engineering

METL 494 (Dr. E. Techtsoonian)
Composite Materials I: an introductory course dealing with fibres and resins; fabrication processes; properties of composites as laminae and laminates; designing with composites.

METL 594 (Dr. E. Techtsoonian)
Composite Materials II: mechanical behaviour of composite materials; tensile and compressive characteristics, toughness; fatigue; impact; environmental effects. Prerequisite: METL 494 Composite Materials I.

Physics

PHYS 305 (Dr. G. W. Hoffman)
Introduction to Biophysics: an introduction for physicists (assumed to have no background in biology) to the basics of molecular biology, followed by selected examples where insights from physical mathematics have helped solve important biological problems. Intended for students with 3rd or 4th year standing in physics. Not for credit for students in the Life Sciences.

PHYS 534 (Dr. R. O. Kornelsen)
Radiological Physics I: a systematic study of the principles involved in radiotherapy and of the techniques required for the application of these principles.

PHYS 535 (Dr. R. O. Kornelsen)
Radiological Physics II: a continuation of Physics 534, including an extension of the topics discussed in that course.

PHYS 536 (Dr. B. Palcic)
Advanced Radiation Biophysics: interactions of radiation with matter in living cells. Description of events following ionizing irradiation; cell survival as a function of dose; survival models. Students will be expected to present a seminar on a pre-selected topic, and participate in class discussions.

PHYS 405 (Dr. L. D. Skarsgard)

Radiation Biophysics: the physical and chemical interactions of ionizing and ultraviolet radiation and their biological effects at the cellular, tissue and whole animal levels. Topics in radiation dosimetry, radiation protection, and the treatment of malignant disease in humans will be included. Prerequisite: fourth year standing in Science, or permission of the head of the Department.

PHYS 406 (Dr. E. A. Evans)

Continuum Mechanics: mechanics of deformable bodies; equations of motion; stress and strain tensors. Basic concepts for solids and liquids with elements of nonlinear mechanics applicable to macromolecular structures such as polymeric materials and biological tissues. Prerequisites: PHYS 206 or 216 and MATH 316 or PHYS 312. Credit may be obtained for only one of PHYS 406 and GEOP 320.

APPENDIX III:

B.C. -BASED COMPANIES CURRENTLY MANUFACTURING AND/OR DEVELOPING MEDICAL DEVICES

ANDRONIC DEVICES LTD. c/o VGH Research Institute 2660 Oak Street Vancouver, B.C. V6H 3Z6 **Telephone: 875-4288** Dr. Jim McEwen	**Medical & Surgical Robotics; Automated Medical Devices**
CHEAKAMUS HOLDINGS LTD. 3666 Yale Street Vancouver, B.C. V5K 1C8 **Telephone:** Dr. Vaclav Hyrman	**Electroconvulsive therapy systems**
C T F SYSTEMS INC. Unit 15, 1750 McLean Avenue Port Coquitlam, B.C. V3C 1M9 **Telephone: 941-8561** Dr. Max Burbank	**Medical equipment; SQUIDS**
EKEG ELECTRONICS CO. LTD Box 46199 Vancouver, B.C. V6R 4G5 **Telephone: 685-7817** Dr. Peter Graystone	**Medical telemetry & instruments**
EPYTEC PROTOTYPES INC. 300-800 West Pender Street Vancouver, B.C. V6C 2V8 **Telephone: 681-0772** Dr. Boye Ahlborn	**Prototypes of medical devices**
FOSTER MANUFACTURING LTD. 107 Bowser Avenue North Vancouver, B.C. V7P 3H1 **Telephone: 986-5674**	**Hospital equipment, stainless steel products**

GENERATION II ORTHOTICS INC. — **Orthopaedic braces & accessories**
128 West 8th Avenue
Vancouver, B.C. V5Y 1N2
Telephone: 879-8606

Lance Taylor

HODGSON ORTHOTICS LTD. — **Orthopaedic devices**
296 East 12th Avenue
Vancouver, B.C. V5T 2G9
Telephone: 872-4224

R. E. Parkinson

JOANCO MEDICAL ELECTRONICS LTD. — **Electronic & Hospital equipment**
TENS stimulators
145 East 13th Street
Suite #704
North Vancouver, B.C. V7L 2L4
Telephone: 988-3020

Dr. B. Brown

LABRON MOBILITY AIDS LTD. — **Orthopaedic appliances**
3425 West 32nd Avenue
Vancouver, B.C. V6Y 1Y8
Telephone: 263-8482

K. A. Labron, President

LLOYDS LEVERS — **Artificial Limbs**
Box 71
Nass Camp, B.C. V0J 3J0
Telephone: 633-2435

LOBEL & SON ORTHOPAEDIC — **Orthopaedic equipment**
418 Columbia Street
New Westminster, B.C. V3L 3W9
Telephone: 533-8210

MED-EX DIAGNOSTICS OF CANADA INC. — **Automated health aids, hospital equipment**
51 Leeder Avenue
Coquitlam, B.C. V3K 3V5
Telephone: 525-3685

Jim MacArthur

MITRAL MEDICAL OF CANADA LTD.
#1 - 11220 Voyageur Way
Richmond, B.C. V6X 3E1
Telephone: 270-7751

Biomedical equipment; cardiovascular supplies

PARAGON ORTHOTIC LABORATORY LTD.
1549 Broadmead Avenue
Victoria, B.C. V8P 2V1
Telephone: 721-1112

Dr. Glen Cornwall

Orthopaedic appliances

PENTLAND, J. A., LTD.
8239 Main Street
Vancouver, B.C. V5X 3L7
Telephone: 324-4011

J. A. Pentland, President

Orthopaedic devices

SCIENTEK HOSPITAL EQUIPMENT
Div. ABC Cassidy
2323 Quebec Street
Vancouver, B.C. V5T 3A3
Telephone: 879-6311

Hospital equipment

SHAPE TECHNOLOGIES INC.
304 - 2080 Maple Street
Vancouver, B.C. V6J 4P9
Telephone: 734-8605

Carl Saunders

CAD/CAM systems for the design of artificial limbs

TELEPRESENCE RESEARCH INC.
655 West 7th Avenue
Vancouver, B.C. V5Z 1B6
Telephone: 873-3300

Endoscopic vision systems

TIAC MANUFACTURING INC.
3080 Spring Street
Port Moody, B.C. V3H 1Z8
Telephone: 461-1626

Dr. H. Malm

Medical electronics

VIVITRO SYSTEMS INC. c/o Cardiac Research Laboratory Royal Jubilee Hospital 1900 Fort Street Victoria, B.C. V8R 1J8 **Telephone: 595-9578**	**Simulation and testing system for cardiac systems**
WECO MANUFACTURING P.O. Box 100 Kamloops, B.C. V2C 5K3 **Telephone: 376-1261**	**Orthopaedic and rehabilitation appliances**
WESTERN CLINICAL ENGINEERING LTD. 5259 Turquoise Drive Richmond, B.C. V7C 4Z6 **Telephone: 271-6288**	**Automated surgical tourniquets and related devices**
WESTERN SCIENTIFIC SERVICES LTD. 11620 Horseshoe Way Richmond, B.C. V7A 2V5 **Telephone: 274-4111**	**Laboratory apparatus and supplies**

APPENDIX IV:

ADDITIONAL B.C.-BASED FIRMS HAVING POTENTIAL INTEREST IN THE DEVELOPMENT/MANUFACTURE/FINANCING OF NEW MEDICAL DEVICES

ACCURATE RUBBER PRODUCTS LTD. **Telephone: 274-9955**
12771 No. 5 Road
Richmond, B.C. V7A 4E9

Ian MacKenzie

ADVANCED LIGHT IMAGING CORP. **Telephone: 433-3422**
#207 - 3700 Gilmore Way
Burnaby, B.C. V5G 4M1

ALAN CRAWFORD ASSOCIATES LTD. **Telephone: 988-2195**
#410 - 212 Brooksbanks Avenue
North Vancouver, B.C. V7J 2C1

AMBREX INTERNATIONAL INC. **Telephone: 464-8879**
125 - 3030 Lincoln Street
Coquitlam, B.C. V3B 6B4

Dr. R.K. Lomnes

AMMUNDSEN MEDICAL SUPPLY LTD. **Telephone: 688-7611**
1062 Homer Street
Vancouver, B.C.

R. H. Ammundsen

ARMEX DISTRIBUTORS LTD. **Telephone: 273-8358**
13120 Bathgate Place
Richmond, B.C. V6V 1Z2

John Hunter

B.C. CANCER FOUNDATION **Telephone: 877-6010**
601 West 10th Avenue
Vancouver, B.C.
V5Z 1L3

B.C. MEDICAL EQUIPMENT LTD. **Telephone: 876-4186**
2106 Main Street
Vancouver, B.C. V5T 3C5

B.C. RESOUCRES INVESTMENT CORPORATION **Telephone: 687-2600**
1176 West Georgia Street
Vancouver, B.C. V6E 4B9

M. G. McKibbin

BAKER HEALTHCARE PRODUCTS LTD. **Telephone: 324-7751**
Suite 214 - 8400 Main Street
Vancouver, B.C.
V5X 3L8

Bruce Opp

BC STEVENS COMPANY LIMITED **Telephone: 321-4121**
8868 Laurel Street
Vancouver, B.C. V6P 3V8

Steve Konstandien

BRENT SURGICAL LIMITED **Telephone: 324-1330**
282 S.W. Marine Drive
Vancouver, B.C. V5X 2R5

COLUMBIA PLASTICS LTD **Telephone: 879-2991**
2155 West 10th Avenue
Vancouver, B.C. V6K 2H7

Ian Howard

CREO ELECTRONICS CORP **Telephone: 437-6879**
110 - 3700 Gilmore Way
Burnaby, B.C. V5G 4M1

Dr. Ken Spencer

CUSTOM PLASTICS LTD. **Telephone: 736-9261**
Division of Fabriform Plastic Ltd.,
3818 Commercial Drive
Vancouver, B.C. V5N 4G2

Johan Wesson

DISCOVERY ENTERPRISES INC. **Telephone: 430-3533**
220 - 3700 Gilmore Way
Burnaby, B.C. V5G 4M1

Charles Kingston

EBCO INDUSTRIES LTD. **Telephone: 278-5578**
7851 Alderbridge Way
Richmond, B.C. V6X 2A4

Helmut Eppich

GRAPHIC CONTROLS CANADA LTD. **Telephone: 277-0303**
Unit 12 - 11171 Horseshoe Way
Richmond, B.C. V7A 4S5

Paul Feduik

HOWMEDICA-MURPHY ASSOCIATES **Telephone: 929-4510**
4033 Mt. Seymour Parkway
North Vancouver, B.C. V7G 1Z8

Terry Murphy

INSET LTD. **Telephone: 261-3111**
Box 46654
Vancouver, B.C. V6R 4K8

Ron Green

JOBST DIVISION **Telephone: 294-6229**
Zimmer Canada
Suite 206, 4585 Canada Way
Burnaby, B.C. V5G 1J9

David Mazzei

LEAR INDUSTRIAL DESIGN **Telephone: 732-6581**
1535A West 3rd Avenue
Vancouver, B.C. V6J 1J9

Kevan Lear

3M CANADA INC. **Telephone: 273-2211**
7100 River Road
Richmond, B.C. V6X 1X5

MACDONALD DETWILLER & ASSOCIATES **Telephone: 278-3411**
3751 Shell Road
Richmond, B.C. V6X 2Z9

Dr. Dennis Connor

MEDICAL ELECTRONICS DIVISION **Telephone: 291-0631**
Instrument Service Laboratories Ltd.
1375 Boundary Road South
Vancouver, B.C. V5K 4T9

MEDILOGIC LIMITED **Telephone: 325-3282**
5755 Beresford Street
Burnaby, B.C. V5X 4S6

Rick Naylor

MOBILE DATA INTERNATIONAL INC. Telephone: 277-1511
11411 No. 5 Road
Richmond, B.C. V7A 4Z3

MOLI ENERGY LIMITED Telephone: 465-7911
20000 Stewart Crescent
Maple Ridge, B.C. V2X 9E7

R. LABORIE SURGICAL LTD. Telephone: 684-3747
Suite 2002, 1055 West Georgia Street
Vancouver, B.C. V6E 3P3

Michael Frith

ROBOTIC SYSTEMS INTERNATIONAL LTD. Telephone: 656-0101
9865 West Saanich Road
Sidney, B.C. V8L 3S1

Jack Wilson

SRC SOFTWARE RESEARCH CORP. Telephone: 727-3744
3939 Quadra Street
Victoria, B.C. V8X 1J5

Annette E. Wright

STARWEL INDUSTRIES LTD. Telephone: 929-1045
1185 Lima Road
North Vancouver, B.C. V7G 1G3

Robert W. Watler

TRIUMF Telephone: 222-1047
4004 Wesbrook Mall
Vancouver, B.C. V6T 2A3

Bill Cameron, Joel Rogers

VENTURES WEST TECHNOLOGIES Telephone: 688-9495
400 - 321 Water Street
Vancouver, B.C. V6B 1B8

James M. Fletcher

ZIMMER RUSSELL ASSOCIATES Telephone: 294-6229
Zimmer Canada
Suite 206, 4585 Canada Way
Burnaby, B.C. V5G 1J9

Bill Russell

APPENDIX V:

SELECTED B.C. AGENCIES WHICH COULD BENEFIT FROM A BIOMEDICAL ENGINEERING INITIATIVE

B.C. Children's Hospital

B.C. Institute of Technology

B.C. Cancer Foundation

G.F. Strong Rehabilitation Centre

Kelowna General Hospital

Royal Jubilee Hospital

St. Paul's Hospital

Shaughnessy Hospital

Simon Fraser University

Vancouver General Hospital

Victoria General Hospital

TRIUMF

UBC Health Sciences Centre Hospital

APPENDIX E

LETTER - PATENT ACT AMENDMENTS

Minister
Consumer
and Corporate Affairs

CANADA

Ministre
de la Consommation
et des Corporations

Mr. David Strangway
President
The University of British Columbia
2075 Wesbrook Mall
Vancouver, British Columbia
V6T 1Z2

Dear Mr. Strangway:

On November 19, 1987, the Patent Act was amended to bring Canada's patent laws into line with those of other industrialized countries. You will recall the public attention given to the provisions which will increase research and development in Canada by innovative pharmaceutical companies.

In line with new Patent Act incentives designed to encourage major manufacturers in the development of medicinal inventions in Canada, I included a further provision which, with the cooperation of you and your colleagues, will act as an incentive to encourage others, including Universities, to conduct additional domestic research which is so important to the development of a viable and internationally competitive Canadian industry.

Enclosed is a copy of the new provisions of the Patent Act. May I draw your attention to Clause 31 which requires me as Minister of Consumer and Corporate Affairs to make payments to each of the provinces and territories for research and development purposes relating to medicine. These payments will be made for four years commencing with the current fiscal period, and the payments will be based on population data published by Statistics Canada.

.../2

House of Commons Chambre des communes
Ottawa, Canada K1A 0A6

I have written to the Minister responsible for science and technology in your Province to provide information concerning the nature, manner and timing of the payments. As the head of a major Canadian University, I trust that you will take advantage of the opportunity afforded by these payments to expand your program to include appropriate research and development projects.

At the same time, I should draw your attention to a new and important initiative. My colleague, the Honourable Frank Oberle, Minister of State for Science and Technology, with the support of the Prime Minister, Canadian business, labour groups, universities and provincial and federal departments recently launched the InnovAction program. One of the program's purposes is to increase Canada's ability to compete effectively in international markets. The importance of research and development to the achievement of this purpose cannot be understated. Consequently, it is with great pleasure that I lend my support to Mr. Oberle's program with these payments to the provinces and territories which are for the purpose of research and development relating to medicine.

I sincerely hope that you will give your support to our Government's efforts to improve the performance of Canadian industry through targeted research and development.

Yours sincerely,

Harvie Andre

Enclosure: 1

c.c. The Honourable Frank Oberle, P.C., M.P.

CONSEQUENTIAL AMENDMENT

Access to Information Act

1980-81-82-83, c. 111, Sch. I

30. (1) Schedule II to the *Access to Information Act* is amended by striking out the reference to "section 74" opposite the reference to the "*Patent Act*".

(2) Schedule II to the said Act is further amended by adding a reference to "section 41.17" opposite the reference to the "*Patent Act*".

(3) Schedule II to the said Act is further amended by adding a reference to "subsection 41.25(3)" opposite the reference to the "*Patent Act*".

TRANSITIONAL

Transitional

31. (1) The Minister of Consumer and Corporate Affairs shall pay to each province for each of the fiscal years commencing in the period April 1, 1987 to March 31, 1991, for the purpose of research and development relating to medicine, an amount equal to the product obtained by multiplying

(*a*) the quotient obtained by dividing

(i) $25 million

by

(ii) the total population of all provinces for the fiscal year in respect of which the payment is made,

by

(*b*) the population of the province for the fiscal year in respect of which the payment is made.

Idem

(2) Payment of any amount under this section shall be made out of the Consolidated Revenue Fund at such times and in such manner as the Governor in Council may, by regulation, prescribe.

Idem

(3) For the purposes of this section, the population of a province for a fiscal year shall be the population of that province on the first day of June of that year as determined and published by the Chief Statistician of Canada.

Prohibition

32. (1) Notwithstanding anything in section 41 of the *Patent Act* or in any licence granted under that section, no person shall,

MODIFICATION CORRÉLATIVE

Loi sur l'accès à l'information

1980-81-82-83, ch. 111, ann. I

30. (1) L'annexe II de la *Loi sur l'accès à l'information* est modifiée par suppression du renvoi à l'«article 74» en regard de la mention de la *Loi sur les brevets*.

(2) L'annexe II de la même loi est modifiée par adjonction, en regard de la mention de la *Loi sur les brevets*, d'un renvoi à l'«article 41.17».

(3) L'annexe II de la même loi est modifiée par adjonction, en regard de la mention de la *Loi sur les brevets*, d'un renvoi au «paragraphe 41.25(3)».

DISPOSITION TRANSITOIRE

Disposition transitoire

31. (1) Le ministre de la Consommation et des Corporations versera à chaque province pour chacun des exercices compris entre le 1er avril 1987 et le 31 mars 1991 pour la recherche et le développement en matière de médicaments un montant égal au produit obtenu par la multiplication de l'élément *a*) par l'élément *b*) :

a) le quotient obtenu par la division de vingt-cinq millions de dollars par le chiffre total de la population des provinces pour l'exercice à l'égard duquel le versement est effectué;

b) le chiffre de la population de la province pour ce même exercice.

Idem

(2) Tout versement est prélevé sur le Trésor selon ce que le gouverneur en conseil peut fixer par règlement.

Idem

(3) Le chiffre de la population d'une province pour un exercice est celui du 1er juin de l'exercice, déterminé et publié par le statisticien en chef du Canada.

Interdiction

32. (1) Par dérogation à l'article 41 de la *Loi sur les brevets* ou à toute licence délivrée sous son régime, il est interdit de se prévaloir

APPENDIX F

PROPOSAL FOR A HOME NURSING CARE INITIATIVE: THE UNIVERSITY OF BRITISH COLUMBIA SCHOOL OF NURSING AND THE VANCOUVER HEALTH DEPARTMENT

PROPOSAL FOR A HOME NURSING CARE INITIATIVE: THE UNIVERSITY OF BRITISH COLUMBIA SCHOOL OF NURSING AND THE VANCOUVER HEALTH DEPARTMENT

Executive Summary

The University of British Columbia School of Nursing and the Vancouver Health Department are proposing a research initiative that would address some of the significant problems related to managing chonically ill patients in their homes. This activity would build upon research that has already been conducted on the management of chronically ill people, and would promote the establishment of interdisciplinary research, as well as collaborative research among nursing and other selected health science disciplines in the University of British Columbia, Simon Fraser University, the Vancouver Health Department, and some of the major hospitals in the lower mainland of British Columbia.

This initiative would respond to a significant health care problem in the province of British Columbia and may have the potential of reducing health care costs by reducing length of hospital stay. It has already attracted considerable interest from industry and offers the promise of substantial economic benefits for the province. As well, opportunities exist for the education of graduate students in the health care field.

Introduction

As of December 1987 there were 29,173 Registered Nurses in the province of British Columbia. Of these 24,915 were practicing; 4,258 were non practicing.

Given the substantial amount of funds allocated to nursing services, careful research with the potential to enhance the effectiveness of nursing care needs to be undertaken. Considerable progress has been made in the development of nursing research in the past decade. However, there is urgent need to increase both the quantity and quality of research that is responsive to the emerging patterns in health care delivery, and the needs of the people of British Columbia. An area of research that needs to be addressed by nursing is technology development directed towards improving the delivery of nursing care in the home.

Patterns of health care delivery, in British Columbia as elsewhere, are changing. There is an increase in home health care, especially the care of chronically ill people. Nurses play a significant part in the delivery of home care services and will be the primary users of technology in this context. While considerable attention has been focused on technology in hospital settings (e.g., monitoring and treatment devices), home health care is a relatively new industry, with the potential for considerable growth. Innovations in technology will make it possible to deliver an increasing proportion of health care services in the home.

Two of the primary goals in the development of this industry should be:

1) to improve the quality of nursing management in the home, and
2) to control the cost of such management.

Areas of Nursing Service in the Home

Three of the main areas of home health care managed by nurses include:

1) the provision of direct nursing care (e.g., carrying out treatments),
2) monitoring of the patient's status, and
3) patient and family education. Nurses are frequently the key educators of patients and their families.

Areas of Technology Development

The development of technology should be targeted to at least three areas:

1) Information management at the systems level. A major problem in home health care at the present time is the way in which data on patients are handled. Nurses are still utilizing a paper system, and must sift through large volumes of paper to get to pertinent information about patients. Considering the complexity of information that is required to make informed decisions about patient management in the home, reliance on a paper system is not efficient. Furthermore, the paper system often precludes access to relevant, up-to-date information, including data from physicians.

What is needed is computerized data on patients, and centralized information in home care agencies. Also needed is a communications system that would allow nurses visiting patients in the home to have access to centralized information in hospitals and home care agencies with the use of passwords to protect confidentiality. Information about a patient could also be transmitted from the home to a hospital or home care agency. Communication networks of this kind would enhance the provision of direct care to patients in the home, as nurses would have access to up-to-date information.

2) Patient teaching. Software packages are needed to help patients and their families acquire knowledge and skills, and reinforce what the patient has learned at a pace that matches the patient's ability and personal circumstances. With chronic illness, a person's learning ability may be compromised. Therefore instruction often has to be repeated. A clinician may not be available at the time the reinforcement is needed, or when the family and patient are most receptive to new information. Examples of areas of instruction include: pain management, special therapies like deep breathing, exercises, using breath control therapy, and colostomy care. Development of appropriate software packages would require the skills of clinicians from nursing and rehabilitation services to ensure that appropriate content is included in these packages.

A substantial number of Canadians who require home health care are from different cultures and are not fluent in English. In some parts of Vancouver, for example, English is a second language for close to 30% of the population. Hardware and software should be developed with these factors in mind.

3) Monitoring devices in the home to help patients monitor their status, and recognize the indicators when professional help or an emergency service is needed. Several home care products (e.g., apnea monitors, glucose monitors) are already on the market. However, as more illnesses are managed in the home there will be the need for further monitoring devices (e.g., monitoring of intravenous

infusions). Patients' decisions about self care could be based on results of monitoring. In addition, interactive computer programmes, developed for home care use, could provide information to assist patients in managing specific situations (such as extremes in blood sugar, or extremes in blood pressure). People could regulate their illness and treatment with greater precision.

Research Focus and Means of Development

The development of technology in home care delivery obviously requires interdisciplinary collaboration to establish capabilities for research, development, implementation and evaluation. This endeavour will require the skills of clinicians from nursing and rehabilitation services who work with patients and their families on a day-to-day basis in both hospitals and community settings, researchers from various health care fields to design projects and develop methods of implementation and evaluation, and experts in the areas of biomedical engineering and communications technology. Ideally, health economists and policy analysts should be part of this initiative to evaluate the impact of technology on both the quality and cost of home health care.

The research capabilities within the University of British Columbia, Simon Fraser University, support from industry, and the clinical skills of practitioners within the Vancouver Health Department, hospitals and other health care agencies, provide the foundation for the development of a program of research that would solve some of the significant problems related to the aforementioned areas. This initiative would provide an excellent opportunity for the training of graduate students in research. At the present time there is a well established graduate program in the School of Nursing at the University of British Columbia. Other departments in the health sciences either have, or are in the process of developing graduate programs.

There has already been extensive consultation with potential industrial collaborators to explore the possibility of obtaining support from industry for a project in home care management. The initiative has been viewed positively and there are indications that support would be forthcoming.

As well, several meetings have been held with practicing nurses to identify priority areas for home care management. As a result of these meetings it was decided that, in relation to patient teaching in the home, examples of areas of particular relevance in the management of care are:

(1) management of pain, discomfort, and insomnia,
(2) management of nausea and vomiting, and
(3) management of diet and elimination.

It was felt this is a long term project that could eventually culminate in a comprehensive package for home care management, including patient monitoring. However, it was also felt that it would be prudent to start off with a pilot project that could be easily evaluated, e.g. the development of an education program on the management of pain and discomfort. This would be a software package designed for families caring for terminally ill patients, and would be directed towards promoting self care in the home. Hardware would also have to be designed for home care use. The initial demonstration project should be conducted in three phases over approximately three years, and include:

1. a preparatory phase, for development of software and hardware, and education of project staff,
2. an implementation phase with patients, and
3. an evaluation phase.

The development of technology that would deal with information management at the systems level and monitoring devices has been discussed earlier, and collaboration among the University of British Columbia, Vancouver Health Department, selected hospitals, Simon Fraser University and industry would facilitate the development of these components of the home care initiative.

What is needed

In order to develop the home care initiative, funds would be needed for a demonstration project in the use of technology in home care. A senior expert in the area of home care management should be appointed to co-ordinate the project. As well, other staff members would be required to assist with the development, implementation and evaluation of the program of research. Funds would also be required as stipends for graduate students. At the present time stipends for graduate students are not available in the nursing sector.

The budget for the staff is estimated as follows:

Budget requirements (yearly basis for a period of up to three years)

Research coordinator	$ 45,000
+ 16% fringe benefits	7,200
Project staff (2 clinical nurses)	72,600
+ 16% fringe benefits	11,616
1 secretary	21,000
Stipends for graduate students	20,000
Consultation (evaluation)	5,000
Project implementation (includes travel & supplies)	10,000
Total	$192,416

J.M. Anderson

University of British Colombia

School of Nursing

APPENDIX G

A TIME FOR REACTION

A SIMPLE PROGRAM TO DRAMATICALLY IMPROVE RESEARCH IN TECHNOLOGY FOR REHABILITATION OF THE DISABLED IN CANADA

A TIME FOR REACTION

a simple program
to dramatically improve research in technology
for rehabilitation of the disabled in British Columbia

The only true success in rehabilitation applied research
comes after the delivery of successful results
to the disabled population.

Although Canada's medical service and health care plan is one of the finest in the world, our application of modern rehabilitation technology to create opportunities for independence for the disabled population is at the trailing edge of our medical research and health care delivery programs. Funding of technical research and development related to rehabilitation lacks consumer oriented priorities and is uncoordinated. The result is that, in Canada, there are a few isolated pockets of excellence surrounded by a vast void speckled with mediocrity and inappropriate technology.

The advanced technological capabilities in the field of rehabilitation that exist in Canada are barely recognized. Entrepreneurial opportunities and the encouragement of industrial growth in this field are minimal, in fact discouraged, by existing federal research policies. Nevertheless, present Canadian social awareness and acceptance of the disabled is the best in the world. This is especially true in the province of British Columbia and therefore, B.C. is in a position, with proper coordination and catalytic prompting, to emerge as an international leader in this field.

The Federal Government is on record as recognizing that "the single and most important principle is that disabled Canadians must have the same opportunity as the able bodied to participate fully in Canadian life". Currently, the disabled consumer has little support to acquire the special training and technical equipment to exercise that opportunity. Consequently, the commercial market for specialized equipment for disabled people is small. It is therefore imperative that the cost of this rehabilitation orientated research be underwritten by the Government, as only then will delivery of services and goods by economically viable to the manufacturers.

THE PROBLEM

Progress in the development and delivery of technology that will enhance the ability of Canadians with disabilities to contribute meaningfully in our society, is sadly lacking.

THE OBSTACLES

I. Money Management: Government funding for rehabilitation research and development is not managed.

The majority of rehabilitation applied research funding is supplied by the Federal Government of Canada. There is no overall management of this funding and consequently no focus for national research efforts. This results in duplication and lack of attention to some critical needs. There is little concern for eventual delivery of the outcome during the research stage, with the sad result that much excellent research work never benefits the disabled. For these reasons, our costs are exceedingly excessive for the results that reach the consumer.

II. Rehabilitation Research Profession: The rehabilitation research profession is struggling for an identity of its own.

The proper applied research environment for rehabilitation technology is both misunderstood and abused, with much funding being wasted in counter-productive efforts. Rehabilitation is a profession not clearly defined. No schools in Canada provide a degree in rehabilitation engineering. Rehabilitation medicine is mostly the domain of therapists. The profession is striving to full a need that is overlapped predominately by the disciplines of medicine and engineering sciences, but it is also the concern of social sciences, physical education, law, economics, architecture and education. Rehabilitation research is not well established, and is usually forced to conform to other disciplines in environments where it does not fit. Technical rehabilitation research is frequently an offshoot of biomedical engineering, which has totally different goals and models for research. Rehabilitation clinical research comes directly from the medical model which carries very different values. In the above cases the research is either technically or medically driven. In most cases the rehabilitation research, because it is treated as a misfit, generally suffers from inadequate funding, space and administrative support.

In Canada today there are many competent but frustrated technical researchers in rehabilitation, but they are generally denied the opportunity to practice efficiently. The problem is not the shortage of professionals in rehabilitation, but rather the shortage of recognition of the need for good rehabilitation research. This recognition would come from projects with properly managed funding that emphasized priorities, consumer end-use, and eventual delivery.

III. Institutions: Institutions dominate rehabilitation research to the detriment of the disabled.

Rehabilitation research is dominated today by institutions: technical research in institutions of higher learning (universities), and clinical research in health care institutions. The health care institutions run from acute care through rehabilitation facilities to long term care centers. There is a token amount in government institutions. Commercial and non-profit organizations account for the small balance.

In medicine, which dominates rehabilitation clinical research, the hospitals are usually inter-related with the universities. In university research, the client relationship is minimized. The universities are primarily educators and science researchers, and so they should be. Moreover, their research mandate is to publish, not to see the consumer benefit. In the university environment, publishing is much more important than to transfer technology. The prestige of the institute is much more important than the prestige of the disabled. **The real needs of the disabled are not usually understood or addressed. Although science research and applied development do overlap, the basic procedures and goals are very different, and this difference must be recognized.**

Good rehabilitation institutes rightfully demand tight scheduling, well defined personnel tasks, predetermined results, and they operate under severe fiscal and time restraints. Good research is a disruption to such standard management requirements. Creative researchers would rather solve problems in rehabilitation than fit into the hierarchy. It is well established in motivation-hygiene theory that the dominant staff attitudes (which result in successful institutional operation) are concerned with policy, administration, supervision, interpersonal relations with peers, supervisors and subordinates, salary, working conditions and security. The successful staff member is concerned with fitting-in and with status. These are not the values or the environment for research achievers. Modern behavioral science recognizes competent creative researchers' satisfaction comes from achievement, responsibility, advancement, growth, and the work itself. The client relationship is also cherished. The researchers' major values are not the institutions' major values, nor should they be. The researcher desires control over scheduling and resources. The institutes do not wish to relinquish that control. The consequence is a low priority for research funding in the rehabilitation institutions, and when the funding is there, the creative researcher has little control over it.

In both the medical and scientific models, the relationship with the private sector product manufacturers and service delivery agencies to the disabled consumer is sadly neglected.

Most technical projects are relatively small (under $100,000). This leads to small pockets of activity in universities and small labs where there is a lack of awareness of the consumer requirements (lack of involvement) and national requirements (priorities). If more effort and concern were invested in demanding more from these projects, (involvement of consumers, concern for eventual delivery), the success of the research would increase dramatically. If university projects concerned with rehabilitation do not involve consumers and technology transfer, then they should be funded as education, not as rehabilitation research.

THE SOLUTION - Funding Management

1. Structure

Provincial policy and priorities for rehabilitation research should be established by a Review Board. This Review Board should consist of two working committees: a Private Sector Committee and a Government Funding Committee.

The Private Sector Committee should consist of aware individuals from industry or private practice. They should be individuals who have no vested interest in delivering the goods or services for Canadians with disabilities, but who have an excellent knowledge of the problems of disabled people through personal experience as disabled, or with disabled family members or employment associates. These members should be successful in commercial practice and understand the business of the delivery of consumer goods or services.

The Government Funding Committee will have representation from the ministries concerned with the funding of rehabilitation or health related projects.

A Working group, with four representatives from each committee, will recommend priorities and policy for the Review Board to follow in their approval process.

The underlying principle will be that policy and priorities for rehabilitation research be set up by the needs of the consumer being rehabilitated, with funding from the appropriate ministries. Policy will not be set by the research community, the manufacturing sector or the service delivery agencies, although all involved will have input through the rehabilitation forum. (See Operation).

All grant applications or contract proposals to the Provincial

Government relating to rehabilitation research should be referred to the Review Board for approval. All rehabilitation research funding applications, processing and operational management would be provided by the concerned ministries, as it is today.

Some programs occasionally interface with the disabled, but are established for other purposes. Whenever these relate to rehabilitation research, they should:

1. follow the Review Board guidelines, and
2. be referred to the Review Board as information only, so as to be used in establishing priorities and guidelines.

All proposals under $25,000 would follow steps 1 & 2 above.

2. Operation

No funding would be approved by the Review Board without qualifying that:

- o technology transfer contacts would be established and maintained in all projects;
- o disabled consumer involvement would be required in all projects. All disabled participants should be paid as part of the research team;
- o provincial government delivery agencies, at the policy level, would be made aware of all projects that might affect their delivery programs in the future.

Exceptions to these rules would have to be well justified.

To achieve good return for the investment, the Review Board should:

1. Give top priority to pilot projects in the consumer environment.

2. Emphasize that eventual transfer of successful technology to the consumer market, and transfer of new services developed to the health care system are the basic reasons for funding the research.

3. Assure that funding is for research, and not for institutional support. This funding should bear the costs of all salaries, space and overhead. Principal researchers should be paid for all their research time from project funding, and not, as it often done, from supporting institutions. The institutions should not have control of the research itself. No funding for rehabilitation research will go to institutions or professional societies for distribution as they see fit. Funding for researchers could, of course, be channeled through the appropriate institutions.

The meaningful long range outcome will be the ability of Canadians with disabilities to participate in the useful and constructive abilities of normal living. This will embrace:

A. capabilities for participation in primary, secondary and advanced education;
B. opportunities for employment and/or entrepreneurial endeavors that lead to economic independence;
C. successful independent living in our communities;
D. the ability to contribute to all facets of society.

This will result in active involvement with, and integration into the social, cultural and economic activities of our society.

The economic long range outcome for the Government of B.C. will be a dramatic reduction in the now expanding cost of care and services to the disabled (including the elderly).

British Columbia has the unique opportunity to quickly move into a world leadership position in rehabilitation research. If we do well with our present base of good researchers, new young people will be attracted into the profession. When this occurs, universities will use their existing funding sources to develop improved curriculum. The Provincial Governments will also need to respond with delivery programs that will use the results of the research to lower health care costs. Industry will respond with products based on good applied research, as the health care cost reductions will create a demand for product availability.

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The inspiration for this proposal ensued from the nationwide activities and programs conducted by the Neil Squire Foundation during the past three years.

(January 1988)

Rapid advances in technology suggest the Review Board should meet for grant and contract review at least four times per year. One meeting a year will be for annual policy and priority review and update. Input from all concerned should be solicited during the immediately previous meeting.

Although input to the Review Board should be open to anyone, one form of established input should come from a rehabilitation forum consisting of representation from:

- individuals with disabilities
- organizations that represent people with disabilities
- rehabilitation researchers
- manufacturers of products used in rehabilitation
- professionals in rehabilitation service delivery

No one of these groups should dominate the forum. This forum could be privately organized and funded.

A networking group should be established to facilitate liaison and communication with other government agencies, including federal, who might be involved with solving problems that relate to the disabled person.

This "Networking Group" could be organized in any appropriate way that allows for proper exchange of information.

Good dedicated researchers can develop exemplary research and development programs, irrespective of their parent organizations, if the funding is realistically available for progressive, well managed work that is responding to the honest needs of the Canadians with disabilities.

THE OUTCOME

This coordination of funding for rehabilitation research should immediately:

1. Minimize duplication in research effort.
2. Highlight areas of need that are not being funded.
3. Minimize vested interests in grant and contract approval.
4. Create improved networking between the ministries involved.
5. Enhance technology transfer and stimulate industrial growth.
6. Supportively emphasize rehabilitation research as a profession.
7. Create a forum for consumer input into rehabilitation research.

APPENDIX

1. In this proposal, the following definitions apply:

   - Disabled: physically, mentally and sensory limited
   - Rehabilitation: to enhance the ability of a disabled person to participate in the useful and constructive activities of a normal life within the limits of the disability.
   - Scientific Research: investigation and experimentation that leads to new facts that are confirmed through testing.
   - Applied Research/Clinical/Research/Development/Research/Rehabilitation: putting the findings of scientific research to practical use.
   - Motivation-Hygiene Theory: formally presented in "The motivation to work" (1959) Herzberg, F., Mausner, B. and Snyderman, B., expanded in "Work and the Nature of Man" (1966) Herzberg, F., and further expanded in "The Managerial Choice: (1982) Herzberg, F. distinguished professor of Management, University of Utah, Graduate School of Business.

2. In the field of rehabilitation, the process is:

Scientific Research	Publish	Applied Research	Technology Transfer	Delivery and Use
In the Institutes		This should be a total process, and successful applied research must be delivered and used. This is applie research and development.		

APPENDIX H

A PROPOSAL FOR ESTABLISHING AN INCREASED CAPACITY FOR THE CONDUCTING OF PHASE I - PHASE II CLINICAL TRIALS AT THE CANCER CONTROL AGENCY

A PROPOSAL FOR ESTABLISHING AN INCREASED CAPACITY FOR THE CONDUCTING OF PHASE I - PHASE II CLINICAL TRIALS AT THE CANCER CONTROL AGENCY

Dr. James H. Goldie
Head, Division of Medical Oncology
Cancer Control Agency of B.C.

May 3, 1988

A PROPOSAL FOR ESTABLISHING AN INCREASED CAPACITY FOR THE CONDUCTING OF PHASE I - PHASE II CLINICAL TRIALS AT THE CANCER CONTROL AGENCY

INTRODUCTION

The development and testing of new antineoplastic agents involves a process that can be divided into at least four distinct phases. The pre-clinical phase includes testing of new compounds against established tumor cell lines in both *in-vitro* and *in-vivo* systems and then toxicity testing in at least two different animal species. If therapeutic activity is identified in appropriate tumor cell lines and if a safe dose in the putative therapeutic dose range can be established, then the new agent is ready to commence the complex process of testing in man.

The first stage in this process is the so-called phase I testing whereby the safe dosage in man is established, the pattern of toxicity identified, and any evidence of therapeutic activity against a clinical malignancy is noted. However, the main objective of a phase I study is to establish safe dosage levels and the patterns of toxicity that the drug produces in patients.

These studies are frequently conducted in association with pharmacokinetic evaluation of the agent. This includes measurement of blood levels of the agent, rates of excretion and metabolic breakdown of the drug, and attempts to identify the principle routes of metabolism of the agent being investigated.

The next stage designated phase II evaluation means testing the drug at a safe dosage in a series of patients with a discrete category of malignancy. In this study, evidence of therapeutic activity against the tumor being assessed is an important component, though ongoing monitoring of toxicity and pharmacokinetics is also an important component of this type of investigation. Usually a minimum of 15-20 patients need to be evaluated in a phase II study in order to identify a minimum level of therapeutic activity with a reasonable order of probability. Agents that pass this next level of testing will then undergo further extensive evaluation. This would include testing in other tumor types, evaluation against larger numbers of patients to establish with greater accuracy the true response rate, and the incorporation of the new agent with other drugs to establish if it can confer additional therapeutic activity to known active combinations. This latter process, which can be considered a phase III evaluation, generally requires a large number of patients who are evaluated in a prospective randomized fashion, and usually this requires the participation of a number of large institutions.

To lessen the length of time that is required in this complex process, increasing use of the so-called combined phase I - II trial in which the safe dosage is established but in a series of patients with the same histological type of tumor. By collapsing the phase I and phase II processes together this may result in information regarding the spectrum of activity of the agent as well as its safe dosage level as part of the same clinical testing trial.

Although a number of components of this process can be carried out or assisted by clinicians working in Medical Oncology Departments and cancer centers, the complex nature of the phase I-phase II trial together with the desirability of carrying out pharmacological studies on a new agent render this a highly specialized activity which requires for its optimum performance dedicated personnel and resources.

THE ESTABLISHMENT OF A PHASE I-PHASE II CLINICAL PHARMACOLOGY PROGRAM WITHIN THE CANCER CONTROL AGENCY OF BC (VANCOUVER)

In order to make most effective use of the very considerable numbers of patients who would be available for phase I and phase II studies within the Vancouver clinic of the CCABC, it will be of considerable importance to establish the nucleus of a clinical pharmacology unit within the Agency. The Vancouver clinic sees approximately 5500 new patients with cancer annually and more than 1,000 of these are started on some type of chemotherapeutic program. Patients who become eligible for phase I and phase II studies include those with certain types of well defined categories of tumor that typically are poorly responsive to existing drug programs (ie melanoma, renal cell carcinoma, certain types of GI tract malignancy, etc) as well as the significant number of patients who fail standard first line chemotherapy program and for whom second line treatment commonly has little in the way to offer in terms of beneficial therapeutic outcome. With appropriate informed consent, well developed procedures that conform to the highest standards of ethical conduct of clinical research, these patients can become eligible for evaluation of new promising antitumor agents.

The Division of Medical Oncology within the CCABC has collectively significant experience in the performance of both phase II and phase I studies, but the ability to expand these studies and to incorporate significant amounts of clinical pharmacological evaluation of the new agent is constrained by the absence of certain key professional staff who could coordinate and expand these investigative activities.

There presently exists, within the Clinic and adjacent British Columbia Cancer Research Center, space that could be used for both the establishment of a clinical investigative unit and appropriate laboratories for performance of drug level and pharmacokinetic profiles in the tested patients. In order to make use of this potential resource, funding for key personnel and supporting infrastructure will need to be obtained.

BASIC STAFFING REQUIREMENTS

The first and most important requirement is to develop funding for an entry level or early career Medical Oncologist with experience and commitment towards phase I and phase II drug evaluation. The understanding would be that approximately 75% of this individual's time would be committed towards the investigational drug program. Because staffing generally within the Division of Medical Oncology is predicated primarily on service needs, it is very difficult to secure the funding for an individual whose prime function is clinical investigation. The entry level salary plus fringe benefits for such an individual would come to approximately $85,000.00 per annum. Commitment would be obtained from the Administration of the Agency to:
(1) Provide the step increases and cost of living increases associated with the individual's progression through the salary scale; and (2) commitment towards assuming the total support of the individual after a period of approximately five years' support. This would be conditional on satisfactory performance and whether or not the industrial support basis would be renewed.

The principle responsibilities of this individual would be to both perform and coordinate the phase I and phase II evaluation of investigational new agents. This would include liaising with representatives from the pharmaceutical industry, the investigational new drug program of the National Cancer Institute of Canada, and with various members of both the intramural and extramural academic community to assist in the performance of tests and analysis of data.

A major responsibility for such an individual would be to carry out further planning, development, and funding procurement for expansion of the basic clinical pharmacology section. This would involve working with the Administration of the Agency and the Head of the Division of Medical Oncology in terms of creating the necessary support infrastructure for a sophisticated clinical pharmacology expertise.

REQUIREMENTS FOR AN EXPANDED CLINICAL PHARMACOLOGY SECTION

With the establishment of a key clinical professional for coordinating these activities, then planning can go forward for developing a more comprehensive infrastructure that would augment the ability to carry out a larger number of clinical trials as well as the performance of pharmacokinetic analysis of data from patients.

A minimum profile for such an expanded section would include a PhD or equivalent pharmacologist or pharmacological biochemist to carry out drug level measurements and to assist in the analysis of the clinical and pharmacological data developed from the studies; a Clinical Research Nurse Assistant to coordinate such matters as specimen collection, a component of patient management, and clinical trials data storage and retrieval; a Laboratory technician of BSC or equivalent experience to assist in the laboratory performance of drug level determinations, etc.

The combined financial obligations to support this basic infrastructure would be approximately $120,000.00 per annum. These three positions, together with the clinical investigator mentioned in the previous section, would provide the basic elements in place for an effective clinical pharmacology section to be established. This section should be able to provide the critical mass to carry forward a significant clinical trials capacity and, on that basis, would be in an excellent position to apply for additional granting from various bodies including industry for further expansion.

BREAKDOWN OF BASIC LEVELS OF FINANCIAL REQUIREMENTS OF A CLINICAL PHARMACOLOGY SECTION

1.	Basic level, one clinical investigator.	
	Initial	$85,000.000 PA
2.	Additional support necessary for more comprehensive infrastructure: One PhD level pharmacologist	$50-60,000.00 PA
	One Clinical Research Nurse Assistant	$25-30,000.00 PA
	One BSC level Technician	$25-30,000.00 PA
	One Sectional secretary	$20,000.00 PA
	Basic expendables and consumable supplies	$50,000.00 PA

CCA BC

Cancer Control Agency
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600 West 10th Avenue
Vancouver, B.C., Canada
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May 27, 1988

Dr. Pieter Cullis
Department of Biochemistry
The University of British Columbia
2146 Health Sciences Mall
Vancouver, BC
V6T 1W5

Dear Pieter:

RE: Funding for clinical investigator in Medical Oncology

I believe the potential for tapping into industrial sources of funding for clinical trials in BC will be substantial in both the short and long term. The major factor in this will be the provisions under Bill C-22 which will require the pharmaceutical corporations to increase their spending on R&D in Canada to 8% then 10% of gross sales. I would conservatively estimate the total gross sales of antineoplastic agents in Canada to be between $80 and 100 million annually, with the expected increase over the next few years (ie by 1992-93) to be in the order of $150 million annually. This would provide a sum of $10-15 million annually that will be required to be made available for R&D in this field under the Bill's provisions.

The Cancer Control Agency of BC, with its Vancouver clinic, is the second largest comprehensive cancer center in Canada, being only slightly smaller than the Princess Margaret Hospital in Toronto. Realistically, there are perhaps four or five comprehensive cancer centers in Canada that might be considered of a critical mass large enough to be major players in anticancer drug development. We are in the position to be highly competitive with these other centers and even if the sums ended up being divided evenly among the leading centers, we would be looking at $2-3 million annually that could potentially be made available for R&D work in BC. I believe the real potential would be higher than that because I think we have a competitive edge with many of the other centers.

At the present moment the CCABC is the second largest contributor of patients to clinical trials through the National Cancer Institute of Canada Clinical Trials Group. Again, the PMH is larger than the Vancouver contribution, but only by a small amount. If you add in the contribution of the Victoria section of the CCABC, then in fact we have a larger patient contribution than that of the Princess Margaret. In addition, our clinical trials researchers contribute patients to such international bodies as the NSABP group based in the United States, the EORTC in Europe, and the Lung Cancer Study Group based in the United States.

May 27, 1988

Dr. Pieter Cullis
Department of Biochemistry
UBC

Our Department has collectively, in the past three years, produced some 200 publications and abstracts, most of it in the areas of anticancer drug development and clinical evaluation. The high profile of clinical research at the CCABC can be best exemplified perhaps by the recognition that one our sections (the Lymphoma Group) received in the recent Rosenthal Address given by Dr. Vincent DeVita, the Director of the US National Cancer Institute. This was in the November 15th issue of Cancer Research, 1987 and I will forward a xerox copy of the article to you under separate cover.

Yours sincerely,

James Goldie

James H. Goldie, M.D., F.R.C.P.(C)
Head Division of Medical Oncology

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APPENDIX I

HOSPITAL COST ACCOUNTING

AN OVERVIEW OF FUNDAMENTAL CONSIDERATIONS

KPMG Peat Marwick

May, 1988

HOSPITAL COST ACCOUNTING
An Overview of Fundamental Considerations

Hospital management and government have come to recognize the vital link between effective cost management and fiscal survival. The introduction and ongoing phase-in of alternative delivery systems, the increasing sensitivity of tax payers, and rates of inpatient utilization make an even stronger case for improved productivity and cost effectiveness. These needs are not new to hospital management. However, the rapidly changing economics of health care have served to increase their importance.

In attempting to deal with the new economics of health care, most hospitals have determined that their existing cost management systems are inadequate or obsolete. Competitive funding pressures are shifting emphasis from a purely departmental or functional basis to a product line basis (patient, service, or program). In reassessing the ability of their cost accounting systems to support cost management, hospital management is questioning whether new systems should be rudimentary, concentrating only on identifiable direct costs for decision making, or if they should be full-scale standard costing systems that are fully integrated with the general ledger system.

Limitations of Traditional Hospital Budgets for Cost Control

The most common budget process in hospitals is the aggregation of line item budgets prepared by department managers. This type of process meets the objective of participatory budgeting, enhancing a department manager's understanding of account structure and levels of expenditure. Traditional management theory indicates that such a participatory process improves recognition and acceptance of budget restraints by department heads.

There are numerous problems of accountability raised in the budgetary process that reduce a budget's credibility and use as a management instrument. Accounting for float pool personnel; personnel loaned, borrowed, or shared by departments; and requisitions costed to departments are several areas where costs attributable to a department may be subject to significant controversy. Just as organizational differences make comparisons among hospitals difficult, inadequacies of cost attribution limit budgetary effectiveness. This lack of consensus on responsibility for costs is so severe in many institutions that participative budgeting techniques have been abandoned. In this kind of situation, the budget becomes a document generated by accounting personnel that is used solely for financial analysis.

Another difficulty is encountered when departmental activities are not adequately measured in the hospital's system for gathering statistics. For example, hospital funding mechanisms generally drive statistical accumulations, but in many instances do not count quality control tests or retests, or differentiate the number of slides in a chemistry test, or reflect the differences (because of procurement costs) between outpatient and inpatient lab specimens. Yet each of these unmeasured statistics has a substantial impact on operating costs. Again, lack of consensus reduces the effectiveness of cost control activities.

Department Productivity and Product Line Costing

Departmental management and related record keeping activities focus on achieving labour and material productivity. In most situations, department managers are unable to control the demand for services - demand is the result of occupancy, program orientation, and physician-imposed treatment patterns. On the other hand, department managers do have a significant influence over how their services are rendered, including the skill-mix, peak and nonpeak activity staffing levels, technologies employed, distribution of administrative and clerical duties, and the creation of productivity targets or incentives. It is the department manager's responsibility to achieve an efficient delivery pattern without compromising the flexibility needed to respond to unusual situations. The demand for services creates the department manager's market, but does little to suggest effective responses to supply economics.

The essential link between department management and per-case costing is the dependence of product line systems on departmentally generated information. The aggregate cost of a hospital admission is comprised of the discrete costs of the many services received by the patient during the hospital stay. As a result, the quality and reliability of product line data depends on the costing of departmental activities. The use of sophisticated techniques in developing costs for activities will improve the quality of product line data.

Cost Accounting Data Sources

In developing a plan for cost accounting information systems, it is crucial to inventory data sources within the hospital. There are several relevant sources of data within a department and in a hospital's accounting system. Compiled data are most often designed to meet the specific needs of a small group of users. As a result, lab managers, chief pharmacists, and ambulatory care administrators retain large volumes of nonintegrated financial and statistical data for operational assessments and as indicators of performance.

This data, for the most part, is actively used by department managers to assist in evaluating personnel, for staffing decisions, supply ordering, maintenance scheduling, and for many other daily departmental activities. There are several features of this data that are pertinent in considering hospital costing techniques:

- It is most often maintained manually;
- It is not integrated with, nor easily reconciled to integrated data sources; and
- It defines activities and accumulates financial and statistical activity measures that are different from the activities accumulated by the hospital's integrated accounting and statistical systems.

In developing an approach to cost accounting, it should be recognized that this data is inherently useful and that it will continue to be accumulated manually if an attempt is made to install a cost accounting system that does not respond to department managers' needs. To avoid redundancy of data collection and to assure that costing data is understood and used by nonfinancial managers, there is a need to comprehend departmental needs, and to contemplate the training and sophistication of users of costing data.

Hospital Costing Techniques

Choices of departmental and per-case costing techniques should be matched carefully with the hospital's and the individual department's complexity. Development of techniques to accumulate nursing costs based on acuity or actual labour and material costs for operating room procedures - while attractive - generate institutional costs that should be carefully weighed against potential benefits. The pressures to reduce costs have brought with them a great incentive to over manage the health care business.

New hospital costing techniques should be viewed in light of the many traditional sources of cost information and analysis. Changes in medical technology have altered some of the uses of cost information, however, the traditional analysis of direct departmental costs and the identification of overhead costs on a departmental basis remain relevant to the costing process. Hospital costing parameters can be briefly summarized as follows:

- **Department management data.** Data provided primarily for internal analysis to enhance the development of costs and funding for services; analysis of alternative courses of action; evaluation of progress toward objectives; and formulation of realistic plans. Traditionally, hospital departments have maintained a wide variety of statistical data to monitor volume and employee productivity. As noted earlier, this data is frequently developed independent of the hospital accounting and statistical systems.

- **Labour productivity data.** Data that is based on the use of scientific principles to ascertain both the cost of labour in productive activities and procedures by which that cost might be effectively controlled or reduced. Because of the labour-intensity of hospitals, a wide variety of labour productivity measures have been developed. These measures vary in sophistication from high levels of aggregation, such as full-time equivalents (FTEs) per occupied bed, to the application of direct labour standards by task for an activity or procedure.

- **General ledger/budgetary analysis.** Budget versus actual comparison by object code, by department is the single most common form of cost analysis. The framework of responsibility accounting provides individual accountability for costs and a system of classification to make the components of cost understandable and readily retrievable.

Standard Costing

Standard costs are predetermined costs of producing one or more units of product or service during a specified time period under current or expected operating conditions. Standard costing has been a little-used costing approach in hospitals. Discussions about standard costing systems, treatment protocols, and productivity incentives now seem omnipresent where they had been essentially absent until recently. Standard costing bridges the gap between measures of costs and activities, and structures a process of setting expectations of labour productivity and material usage. It is the foundation of performance analysis both of departments and product lines. It is a powerful management control device in a labour-intensive business that sets performance expectations both for departments and product lines, and encourages individual achievement.

HOSPITAL COST ACCOUNTING
An Overview of Fundamental Considerations

Standard costing can best be illustrated by focusing on flexible budgeting in hospitals. Hospital cost budgets, built principally on historical trends, have been largely unrelated to volume considerations. In some instances, even basic volume indicators such as patient days have not been linked to preparation of the cost budget. Costs have been viewed as largely fixed, and general productivity indicators such as FTEs per occupied bed have been dismissed as unreflective of the unique aspects of a hospital's operations. Flexible budgeting is not really achievable without standard costing, which sets reasonable expectations as to employee performance under variable volume levels.

In order to achieve efficient management, proper control, and the ability to know what it should cost to provide services, benchmark costs and cost patterns must be determined, and an approach to predict those costs should be developed. One method for developing predictable costs and procedures is through the use of labour standards. The accuracy of costs, particularly in hospitals, is to a great extent dependent on the accuracy of labour standards.

Labour Standards

Labour costs represent, on the average, 70 - 80% of all hospital operating costs. The concentration of these costs in technical and clerical areas makes them fertile for the development and application of labour standards. Indeed, labour standards are now available for most areas of hospital operations. Dietary, radiology, laboratory, housekeeping, renal dialysis, pharmacy and physical therapy are several of the areas for which labour standards have been developed.

Labour standards reflect the time that it takes an average well-trained employee to perform a task at a normal work pace. They provide more accurate facts for present and future action, because they measure work (tasks) - not people. In applying labour standards, there are many categories of time distribution which should be considered:

Normal or Standard Time. The main building block of a standard costing system is the amount of time an activity or task requires. There are two related measures of that amount of time - normal time and standard time. Normal time is the period required to complete an activity under routine conditions, without interruptions or minor delays. Standard time is an average time measurement, incorporating within it minor disruptions of work flow. Normal and standard times can be viewed as related performance guidelines, the former somewhat narrower and less flexible than the latter.

Applied Hours. Applied hours is the amount of time accounted for either by a specific accumulation of work or a summarization of the number of activities performed that is multiplied by the standard (or normal) time per activity. Because of the large number of activities that are performed by many hospital departments, specific work reporting is generally not practical. As a result, hours worked by or paid to department personnel will generally be measured against an applied hours figure that is determined by the actual volumes of activities multiplied by standard times.

Worked and Paid Hours. Two key components of payroll cost used in standard costing are worked and paid hours. Worked hours represent the time spent to perform business activities that are related to employment. Paid hours represent all employment time that is paid for, including vacation, sickness, holiday, overtime, jury duty, etc. Because nonworked hours are typically outside the control of the department manager, it is important that they be excluded in attempting to measure productivity.

Absent Time. The number of hours the employee was absent from work for paid personal reasons represents absent time, i.e., sickness, vacation, holiday, jury duty, conferences, etc.

Loaned Time. Loaned time is the number of hours the employee was loaned to another department, or another section of the same department, in lieu of performing routine departmental tasks for which standard time has been measured.

Supervisory Time. The number of hours the employee was performing supervisory duties is placed into this category.

Unmeasured Time. Based upon the design of work standards, there will be departmental activities that are not measured. For example, several published sources of radiology labour standards gauge only technician time. Supervision, clerical work, and patient transportation are excluded from those standards. Care must be taken to account for unmeasured work in comparing applied and worked hours.

Unmeasured - Other. This category represents the number of hours the employee was off standards for reasons such as no work, training, meetings, and unavoidable delays (i.e., computer down-time, equipment trouble, clean up, etc.).

Skill levels are also important factors in applying labour standards. Skill, in this case, refers to the ability of the individual to perform the particular task at hand. Standards are formulated based on an assumed skill level or mix of skill levels. As a result, skill levels must be considered in the development of standards. For example, labour standards for pharmacy may anticipate a mix of 50 percent pharmacists and 50 percent technicians for accomplishing the department's work. Higher percentages of pharmacists may permit good performances against standard hours without yielding departmental economies.

The standard costing highlights several areas of management interest - the ratio of worked to paid time (the "worked hours index"); the ratio of earned to available hours (the "productivity index"); and, the amount of unmeasured work. This would become significantly more complex if departmental activities and the application of standards by shift and skill level were differentiated. Also, productivity measurement could be more exact by requiring time reporting by activity, or by incorporating clerical, supervisory, or administrative time in the setting of standards.

There is an additional factor in developing worked and paid hours data which are not addressed, and that is loaned time - employee time borrowed from or loaned to other departments. Borrowed and loaned time is frequently substantial in relationship to the total worked hours in a department. Float nurses are, perhaps, the most common example.

Similar frequent occurrences of employee sharing include clerical accounting personnel and laboratory technicians that serve more than one laboratory cost centre (e.g., microbiology and haemotology). Careful and reasonably accurate accounting of borrowed and loaned personnel is, in these instances, essential to the quality and consistency of productivity tracking techniques.

In applying labour standards, the fundamental decision lies in the complexity needed to produce useful data for decision-making. It is clear that hospitals can over manage from a cost accounting and productivity standpoint. In most situations, standards development at a sub-task level, installation of a time-keeping activity, or inclusion of clerical or supervisory time in developing standards may cost an institution far more than their potential benefits. The key challenge to hospital managers is the creation and use of productivity tools that encourage management efficiency without creating excessive record keeping requirements. "Simple" monitoring of the productivity index by department will often prove to be an effective, easy to maintain approach. Similarly, attempts to reduce the level of unmeasured work, or to reverify labour standards through management engineering studies must be tempered by the potential benefits to be realized. In recognizing the inexact "art" of standards in a hospital setting, hospital management can achieve efficient application by keeping an overall focus on the hospital's needs and complexities.

Material Standards

In comparison to labour standards, the development and application of material standards have significantly lower priority, because hospitals and health care providers generally are labour-intensive businesses. The lack of information systems support for many pharmacy and supply requisition systems reinforce the reluctance to account for supply usage by activity. However, in areas of the hospital such as radiation therapy, renal dialysis, operating room, and nuclear medicine, an understanding of supply costs is essential to the costing of activities (i.e., tests, procedures, etc.). Material costs are important in the assessment of program profitability and in decision making among competing technologies. While material standards are often viewed as having limited usefulness to hospital management, their relative importance increases substantially in specific operating areas and as services provided become more complex.

Composite Costs-Per-Procedure

Having developed and applied labour and material standards by activity, a bridge to the costing of individual cases or average treatment patterns (protocols) is still needed. While standard direct costs for labour and materials provide a good basis for case-mix costing, an algorithm is required that distinguishes between patient-specific and other activities, and that provides for the absorption of all hospital costs. There are a series of components to be considered that comprise the cost of a hospital discharge or case:

- The direct costs of patient-specific activities;
- Indirect costs of patient-specific activities, including unmeasured work, and the direct costs of other activities (nonpatient-specific activities such as retests or quality control tests); and
- Overhead from departments that do not provide patient-specific services.

With labour and material standard costs, management is prepared to build composite costs-per-activity. To accomplish this, the following detailed computations are necessary:

- Allocate overhead costs to departments providing patient-specific and chargeable activities.
- Compute absorption rates based on budgeted or actual activity volumes to assure full absorption of indirect and overhead costs.
- Allocate indirect and overhead costs based on direct costs, or another basis, to direct patient activity.

For example, components of overhead may be allocated using direct labour costs rather than total direct costs, keeping in mind that any allocation of overhead is an inexact process at best. These types of cost analyses, therefore, must be weighed very carefully before expending time and resources.

Case-Mix Costing

By developing composite costs-per-procedure, significantly more accurate unit costs of activities are available for producing case-mix analyses. At this point, however, a decision is required on whether costs will be generated by case on an ongoing basis or whether special ad-hoc analyses will be carried out of specific cases. The former has the advantage of continually monitoring the costs per case but requires a very expensive system to consolidate all the cost generating activities for a patient in a single electronic record. Unlike the U.S. system, where this is done as a matter of course for billing purposes, no such need exists in Canada. An ad-hoc analysis of the costs of specific cases, however, while being much cheaper to implement, does not give an ongoing record of the costs of individual cases. We believe, however, that most of the benefits of a case-mix system may be derived from this approach.

The Conceptual Design of a Standard Costing System

In discussing standard costing techniques in hospitals, three levels of information have been identified - productivity data at the department level for direct labour and materials; composite costs-per-procedure, including full absorption of indirect department costs and overhead; and case-mix costing.

As discussed earlier, effective approaches to costing can meet departmental needs to assess productivity, while supplying a basic element for improved costing of patient services.

Thus, care should be taken to meet both departmental needs, and management objectives of reducing costs. The "link" between productivity and case-mix costing makes it clear that departmental needs should be met in developing costing approaches. Superimposition of productivity reporting on existing departmental record keeping will defeat the purposes of developing those reports. It is important therefore, that there is full departmental acceptance of productivity measures to avoid undermining and threatening the integrity and usefulness of composite and case-mix costing based on that data.

Summary

Interest in cost reduction, productivity and product line costing has led government and hospitals to an important basic need - standard costing. The complexity of hospital operations and the pace of technological change in the health care industry make standard costs difficult to develop and maintain. But there is no easy alternative. In areas where charge levels are often unreliable indicators of costs, (e.g., nursing and operating room), product line costing may prove misleading in the absence of standards. More importantly, the ongoing assessment of productivity in a complex, labour-intensive business is essential to good management.

Hospitals develop a wide variety of data to measure operating and financial performance. This data, both financial and statistical, is maintained at various levels within the organization, and is often not integrated or reconciled. Cost budgets are often built without regard to activity volumes.

HOSPITAL COST ACCOUNTING
An Overview of Fundamental Considerations

Hospital global budgets are not tightly linked to cost, and it has become increasingly evident that an integration of costing and operating measurements is necessary to manage health care. Standard costing provides that necessary link. Using labour and material standards, hospital managers can assess productivity in a manner that is understandable to employees.

In setting out to apply standards, managers should keep in mind the following:

- Costing is an art, and inherently inexact;
- Standard costing is ineffective without the support and cooperation of individual departments;
- There is more to be gained from creating productivity incentives or goals than controlling (or attempting to control) behaviour;
- If standard costing approaches do not meet departmental information needs, their usefulness is substantially impaired;
- New systems or applications should use existing sources of data, with corrections and improvements to those sources as needed. Redundant data minimizes the usefulness of data;

- Standards must be updated to reflect the dynamic technological changes in the delivery system;
- Keep it simple and understandable; and
- Do not create a measurement device that is more complicated than the activities measured.

Intelligent application of productivity techniques and standard costing approaches in hospitals is vital to reductions in health care cost. The effectiveness of their use will be dependent upon thoroughness and common sense in their application, and the willing participation of employees. At the same time, these approaches offer an effective integration of the disparate data sources within an institution, and the opportunity to respond successfully in a substantially changed operating environment.

APPENDIX J

CONCEPT

PERSONAL LIFETIME ELECTRONIC HEALTH RECORD

CONCEPT

PERSONAL LIFETIME ELECTRONIC HEALTH RECORD

A BRIEF DISCUSSION PAPER
PRESENTED TO
THE SCIENCE COUNCIL OF B.C. (HEALTH TECHNOLOGY GROUP)

MAY, 1988

BY

E.J. FINN, PH.D., M.B.A., CMC

SENIOR MANAGER
PEAT MARWICK CONSULTING GROUP

CONCEPT: PERSONAL LIFETIME ELECTRONIC HEALTH RECORD

GENERAL BACKGROUND:

Personal health records are stored in a variety of locations, including hospitals (treatment records), doctor's offices (visit/treatment records) , public health clinics (immunization, family medical history, genealogy and radiology records), pharmacists (drug usage history, allergies), dentist's offices (visit/treatment records), and several other locations. As patients frequently move, their health records, and the number of repeat examinations they must endure in order to refresh the record on each move, are "lost". This lack of information occasionally causes problems, where, in an emergency, a physician must either wait for diagnostic test results, or make a spot treatment decision on a "best guess" basis. Also, the genealogical context of a disease problem (such as hereditary links) is often lost in these moves. It is estimated that 20% of the North American adult population move locations each year.

While several attempts have been made to establish wide-area data communications links to offset this problem, these are much akin to "bringing the mountain to Mohammed". Rather, recent advances in LSI chip design and minituarization have made it possible to have the patient become the prime keeper of his/her lifetime health record, much as he/she now keeps a passport. This concept involves distributing the medical record database (and with it, a significant burden of responsibility for security, maintenance and accuracy) to the patient/owner. If access to this data requires individual's consent, security and confidentiality problems over access to health records will be minimized and/or avoided.

PRODUCT DESCRIPTION :

The concept may be best described as the "Smart Card" , where a credit-card-sized identification card contains an embedded microprocessor and memory storage elements. On each treatment, the card is inserted into a card-reader attached to a computer, which, upon authorization by the patient, interrogates the demographic, genealogical and health record information stored there. At completion of the treatment, the card data is updated to include the last diagnosis, treatment and patient response. A copy of the data is retained by the treatment agency, but the master record remains with the patient.

POTENTIAL MARKET SIZE:

The developed countries have populations which are highly transient and demanding of the highest standards of medical care. With the exception of the U.S., they also have publicly-funded medical plans and governments which are sensitive to the spiralling costs of health care, including diagnostic services, drugs and other health treatments. These include the populations of Western Europe, North America, Australia/ New Zealand and Japan - a total of over 650 Million people.

In mass production, there is reason to believe that an electronic "smart-card" would be an attractive option for government-funded health care records management programs in all of these countries. The concept may, if the smart-card concept is extended slightly to act as a charge card for medical services covered by the carrier, also be attractive to insurance carriers in private health-care schemes.

COMPETITORS:

Groupe Bull (Honeywell Bull) of France has recently developed an electronic "smart-card" based on microprocessor technology which is being used in pilot projects in France (see attached advertisment). It is in limited use in Britain and the rest of Europe, but is being backed by European governments as an adjunct to the free movement of Europe's labour force throughout EEC countries. Little else is known about this product, its strengths and limitations, it's cost and distribution.

In Britain, a competing but similar "contact list smart-card" technology from GEC (General Electric) is being piloted in university-sponsored studies in South Wales. The significant differences between these technologies are the latter's ability to be "read" when placed near a reader device and a larger storage capacity than the 64,000-character limit of the HB card. The Welsh studies involve patients of GP's and pharmacists, and the smart card includes demographic, blood group, allergy and drug history data. A byproduct of these studies has been easier access to epidemeological and consumer drug use data. A modification of the ICD-8 diagnostic coding scheme (called the Oxsmith coding scheme) has been developed for use by general practitioners. Various add-on coding schemes have been suggested to handle the coding needs of specialists, clinics and hospitals.

The technology is evolving rapidly as the race for product acceptance and market share begins in earnest. However, the technology is as yet in it's infant stages.

COMPANION AND/OR PRE-REQUISITE TECHNOLOGY:

There are several pre-requisites for the use of this technology, including:

- An internationally-agreed data definition set for health data storage (including disease codes (Oxsmith-plus, ICD-9 plus ?), family tree definitions, treatment codes, results codes, physician and hospital I.D's and many other items
- An agreed technology, including microprocessor architecture and function, memory architecture and the physical read/write devices which manipulate data on these cards
- Agreed standards of data security for access to this information (particularly in emergency situations)
- A replacement / backup mechanism for lost/stolen /damaged "smart cards". This would involve an entirely separate business for a public or private "data bank" where customers could deposit data to be used in such emergencies.

THE OPPORTUNITY FOR CANADA

Canada would appear to have significant advantages in competing in this marketplace. These include:

- It has a publicly-funded health-care coverage for its population, with agreed standards for diagnostic coding
- It has access to and experience with the latest chip technology originating mainly in California

- It has a well-established reputation in the development and marketing of information and communications technology

- It's population base is clustered in a limited number of urban areas, making a pilot project more feasible to implement

- It is about to enter into a free-trade agreement with the U.S which will allow Canada unfettered access to the North American technology marketplace

THE NEXT STEP

The next step would appear to be a feasibility study of the concept. This study would evaluate the feasibility of establishing a smart-card industry in Canada to serve, initially, the entire North American market. This would include an evaluation of the potential market, strengths and weaknesses of existing and new smart-card technologies, barriers to product acceptance and use, entry costs (including R&D, technology licenses, production facilities, marketing, distribution and pilot studies) and a business plan and organization for the development and marketing of the product

This is a computer disguised as a credit card.

Although it's the same size as other credit cards it contains a micro-processor in the left hand corner.

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APPENDIX K

A(N INCOMPLETE REVIEW OF MEDICAL STANDARDS)

DRAFT

A(n Incomplete) Review of Medical Standards

Sean McLinden and Gina D'Ascenzo Carlos
University of Pittsburgh
May 1, 1988

The nice thing about standards is that there are so many to choose from -- Edsgar Djikstra

1. Introduction

From the time of the introduction of computers it seemed only natural to explore the role of computing systems in medical care. Represented in the care of the hospitalized patient are all of the major areas of computer science including database management and intelligent retrieval, resource management and planning, graphics and imaging, distributed processing, signal processing and analysis, and artificial intelligence applications. The hierarchical administrative structure of the hospital simplifies the mechanism by which "new" processes make their way into general use and allows for controlled deployment of these processes in such a way that they can be monitored and modified with relative ease. In addition, there is the preception that a great deal of wealth exists in the health care system though in practical terms, this lies outside the control of this structure. But in spite of an environment which clearly suggests a role for the computer, relatively few systems have actually been integrated into the mechanism of patient care delivery. In most hospitals data entry and processing is handled by data entry personnel who are outside the loop of of patient care delivery and true integration does not exist (with rare exception; notabl among the exceptions is the widespread incomrporation of microprocessor technology into bedside care systems).

Recently, a panel at the 1988 AAAI Spring Symposium on Applications of Artificial Intelligence in Medical Care, discussed reasons computer-based information systems were not in widespread use in medical care settings despite nearly 20 years of research in this area. Principle among their conclusions were two of pertinence to this paper.

- the lack of interface between the physician/user systems and other hospital information systems such as the clinical laboratory data systems, medical records, scheduling, and ADT
- a lack of relevance in many of these systems to the specific problems of the users

The second point was iterated by Slack in his essay entitled *The Soul of A New System*, where he noted that in spite of the tremendous success of the AI-based Acid-Base and Electrolyte Management Systems (ABEL) [1], in predicting the effects of various abnormalities on kidney function, this system had failed to make its way into clinical use, while a

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This document is excerpted from a paper entitled *An Integrated System for Medical Patient Management* which describes on-going research into the incorporation of artificial intelligence techniques into hospital information systems (HIS). It is reproduced for use by members of the *IEEE Medical Data Interchange Committee (MEDIX)* solely for IEEE MEDIX business and is not for duplication or use for other purposes without the written permission of the authors. Inquiries should be addressed to Sean McLinden, Decision Systems Laboratory, 1360 Scaife Hall, Pittsburgh, Pennsylvania, 15261-2036, (412) 648-9600. Internet: sean@cadre.dsl.pittsburgh.edu.

much less ambitious PC-based electrolyte system was used, heavily, in many Intensive Care Unit (ICU) settings across the country [2]. One explanation for this, he concluded, was that the designers of ABEL had not paid enough attention to what the user needs actually were. This concern of a lack of relevance to clinical practice became so important to the developers of CADUCEUS that an extensive retooling of the system was begun following the results of over a decade of study into the methods of information exchange between various members of patient care team which showed a serious lack of attention to the uses of clinical information by these *actors* [3,4]. The resulting system is described, briefly, in a subsequent section.

The following is an attempt to catalog some of the many on-going projects and research efforts which might have some relevance to designers of patient care systems and standards. It is not intended to be a detailed analysis of any of these systems. Commercial systems such as the Technicon Medical Information System (TMIS) the Hewlett-Packard Electrocardiographic Language (ECL) [5,6] were excluded either because they are proprietary or insufficient information was available in the published literature. The lack of available literature was also the reason for the exclusion of a number of non-commercial efforts such as the CRIS/Core language of medicine, the Korner Commission Report, the READ Clinical Classification, and the Veteran's Administration Core Data Dictionary (the latter is available from the Veteran's Administration but a copy was not obtained prior to this draft publication).

The organization of the paper summarizes progress in three major areas where research has identified items which might be of concern to standards developers: complete patient care systems, data dictionaries and medical thesauri, and interfaces and transaction models.

2. Complete Patient Care Systems

A number of systems exist which utilize some form of the medical record as the focus for the management of patient care information. Many of these systems provide additional services such as progress note generation and alert mechanisms for abnormal laboratory values or possible drug interactions. To some degree or another all of these systems utilize some clinical concept as the atomic unit of a meaningful transaction.

The COmputer STored Ambulatory Record (COSTAR), developed by Barnett and colleagues was a pioneering effort to develop an electronic record of patient care for a large clinic population [7,8]. The output from COSTAR includes text reports, generated by the system, which summarized patient "encounters" with physicians. COSTAR is implemented in MUMPS [9], a database language developed at the Massachusetts General Hospital which has gained widespread acceptance as an implementation environment for medical databases.

The Problem Oriented Medical Record (POMR) [10,11], developed by Larry Weed defined an electronic medical record which organizes information into problem areas which can be used to intelligently sort patient data from the history, physical examination, and diagnostic laboratory [12]. The structure of the POMR formed the basis of PROMIS, a management information system, later developed by Weed and others [13,14], which was capable of generating automated progress notes and suggestions for treatment.

Fries' Time-Oriented Patient Record [15] and efforts by other researchers formed the substrate for efforts such as ARAMIS, a national longitudinal database of rheumatologic disease [16], and of The Medical Record (TMR), implemented at Duke University by Hammond and Stead [17-20]. A similar approach has been taken by MacDonald and colleagues at the Regenstrief Institute for Health Care [21].

A somewhat different strategy is being is being used by Tolchin and co-workers at Johns Hopkins University [22,23]. In their system, Remote Procedure Calls (RPC), are used to massage databases implemented on machines of different purposes and using different record formats. The common link is not the record, but a uniform networking protocol for accessing heterogenous records [24].

Perhaps the most successful implementation of an electronic medical record, to date, has been the HELP (Health Evaluation through Logical Processing), system designed by Warner, Pryor, Gardner, and Clayton [25-27]. Now undergoing substantial revision, HELP is built around the concept of objects and object frames which are a set of rules to cover the manipulation of the objects. These frames describe discrete units of clinical information which can be approached as problems on a patient problem list. For any object of a particular type a frame slots exist which describe a display function for that object, and other operations to be done when objects of this type are created or manipulated. These frames can be included in other frames so that a hierarchy of objects and object types can be created. Management rules can be incorporated into these frames and frames can be linked to other frames or objects to other object in order to provide some mechanism for internal consistency in the database.

At the University of Pittsburgh, lessons learned from earlier work on INTERNIST-1 and CADUCEUS are being applied to the design of a hospital-based diagnostic and management resource which utilizes an "expert system" to oversee the management of the medical record. Like these other systems, the patient's medical record is the focus of the systems' activity, however in this model, both (patient) data driven and (physician) hypothesis driven strategies are used to create a state of expectation through which incoming data is filtered. Clinical hypotheses are used to interpret and validate data prior to its entry into the record. Daemons for maintaining both internal consistency, within a record, and for examining consistency between records separated either spatially or temporally are under development.

2.1. Comments

Each of these systems describes an integrated approach to the maintenance of information pertinent to care of the patient. In contrast to the traditional form of hospital information system, these systems rely, heavily, on some form of stored medical record which is used to characterize the interactions between users and the system. It is notable that in spite of what probably amounts to more than 1000 many-years of development few, if any, of these systems have gained widespread acceptance outside of their parent organizations. Perhaps the single biggest reason for this is the fact that deployment of these systems requires an institutional commitment of such scale that few health centers would be capable of supporting these. In many medical centers, the clinical laboratories, diagnostic and imaging services, pharmacy, and even nursing, may be contracted to private organizations with their one administrative and information infrastructure. A standard such as MEDIX could provide a substantial impetus toward information sharing among these concerns. On the other hand institutions whose organization is characterized by such fragmentation may, in fact, not be the places to study the nature of useful medical information transactions. It is in these larger, comprehensive systems, where fewer impediments to information exchange are found, that we should look to get a more clear understanding of what are the atomic units of medical information exchange.

3. Biomedical Thesauri and Data Dictionaries

For many years organizations such as the College of American Pathologists have recognized the need to move toward a standard for the representation of medical concepts using dictionary of acceptable terminology with meanings agreed upon by all members of the profession. Almost immediately it became apparent that a simple listing of acceptable terminology was insufficient. In many cases the taxonomies which were used to organize the terminology broke down, for example, is *diabetes mellitus* an metabolic disease? a

vascular disease? a systemic disease? a neurologic disease? or, all of the above? Clearly what was needed was not so much a list of terms, but a mapping of concepts into a terminology suitable for expressing those concepts. Although many of these concept maps, or thesauri, now exist in many medical subspecialities, a few should be mentioned in this context.

3.1. Systemic Nomenclature of Medicine (SNOMED) [28,29]

In 1965 the College of American Pathologists began an effort (then called *Systemic Nomenclature of Pathology*, SNOP). to systematize the descriptive terminology found in pathology reports in an attempt to anticipate the eventuality of electronic medical transactions. A priority for this effort was recognized by the Division of Computer Research and Technology of the National Institutes of Health, and in 1976-77, the first edition of SNOMED was published. Today, SNOMED consists of textual descriptors (*lexemes*) and numeric codes which are organized according to a taxonomy with seven axes. These are *topography, morphology, etiology, function, disease, procedure*, and *occupation*. Each descriptor is a four-to-six digit number preceded by the initial of the axis under which it falls. The significance of the digits is from left to right, for example, the code for *tuberculosis* is D-0188, and for *acute miliary tuberculosis*, D-01884. An optional field can be used to list cross references to related lexemes which may not be derivable from decomposition of the considered descriptor. For example, the listing for *endemic goiter* appears as:

M-71660 Endemic goiter (T-96000)

where T-96000 is a pointer to the SNOMED lexeme *thyroid gland*.

SNOMED descriptors are employed by most pathology laboratories, today, although in many cases these supplement the free text record. At least one attempt has been made to map between SNOMED terminology and other classification schemes such as ICD [30], with the impediments to progress having been outlined by that author.

3.2. American Medical Association CPT-4/CMIT [31,32]

Motivated by the need for standardization of terminology for communication between physicians and for representing testing and procedure data, the American Medical Association has developed two standard nomenclatures which have are in widespread use. The Physician's Current Procedural Terminology, 4th Edition (CPT-4), consists of descriptive terms and identification codes for thousands of medical, surgical, pathological, and radiological procedures and findings which might be used in clinical practice. The popularity of CPT-4 has led to its adoption by the insurance industry as the standard for identifying patient care procedures on insurance forms. Qualifiers and modifiers can be used to represent exceptions to the standard terminology.

While CPT-4 is strictly an index, Current Medical Information and Terminology (CMIT), provides a framework for the description of medical terminology, including diagnoses and treatments. Each item in the CMIT code may have associated fields which describe other relevant data, for example, a CMIT description of *miliary tuberculosis* looks like:

TUBERCULOSIS, MILIARY 03 4899

at	Tuberculosis, disseminated hematogenous
et	Massive invasion of *Mycobacterium tuberculosis* in blood.
sm	Onset sudden; malaise; anorexia; chills; nocturnal sweats; cough usually mild; expectoration; dyspnea severe with progression; weight loss, prostration.

sg	Most common in early childhood; onset soon after primary infection; in later life associated with virtually any form of chronic tuberculosis; cyanosis; pulse rate increased; rales, possibly scattered; possibly friction rub; enlargement of lymph nodes; distention of abdomen; possibly enlargement of spleen; fever; later, features of meningitis as nuchal rigidity, positive Kernig sign, disorientation, stupor, coma.
lb	Culture of gastric washings positive for *M tuberculosis*; tuberculin reactions varied; ESR increased; leukemoid reaction possibly positive. *Ophthalmoscopy:* choroidal tubercles.
xr	Nodules throughout lung; later, conglomeration, cavitation.
cr	Prognosis: serious; accounting for most tuberculosis deaths in first 4-5 years of life.
pa	Tubercles in lungs, lymph nodes, liver, spleen, kidney, bladder, adrenals, prostate, seminal vesicles, fallopian tubes, endometrium, meninges, retina. *Chronic form:* lesions usually less widely distributed; bone, joint, renal lesions; serous effusions. Horne NW: Tubercle 50(Suppl):2-12, 1969

Figure XX: CMIT descriptor of miliary tuberculosis. *at*= additional terms, *et*= etiology(ies) or suggested cause(s), *sm*= symptoms or complaints, *sg*=physical signs, mental status, historical findings, *lb*=laboratory data, *xr*=laboratory data, *cr*= disease course including prognosis and complications of treatments, *pa*= pathological findings.

3.3. Uniform Medical Language System (UMLS) [33] and MeSH [34]

The National Library of Medicine's Uniform Medical Language System is an attempt to define a dictionary of medical terminology with commonly accepted meanings as a way of standardizing information in the medical chart. Among the goals of this effort is an an interface between the data structures of INTERNIST-1/QMR, DXplain [35] and the HELP system. UMLS is not so much a specification for an electronic medical record standard as it is a specification for standardized building blocks of an electronic medical record

As stated in the UMLS Request for proposals:

> The intent of UMLS is to provide the used direct integrated access to many sources of automated biomedical information. The purpose of this is to focus on the interaction between the user and the system. This will include analysis of the information needs of users of biomedical databases, analysis of the language used to express these needs, and analysis of the relevance of search results. It will involve a study of the characteristics of intelligent and effective human computer interaction, including informative feedback, iterative search refinement, and useful organization and display of such results.

The UMLS effort includes the construction of a Metathesaurus of terminology for a broad range of applications to the biological sciences. An Information Sources Map will be created in order to allow users to determine relevant sources of information and the structure of queries to these sources. Included in the current achievements of the UMLS effort is a database of disease descriptions for over 800 diseases which includes information regarding etiologies, demographics, and manifestations. Significantly, wherever possible, the database record includes a mapping to equivalent terminology in other major databases such as MeSH, CMIT, SNOMED, and ICD9-CM.

Methods for mapping queries between various databases including HELP, DXPLAIN, and QMR/INTERNIST-1 have been developed by Miller and Masarie and colleagues at the University of Utah [36,37], and by Evans and Carbonell [38] at Carnegie-Mellon University. Curiously, both of these efforts arrived, independently, at a frame-based structure for a dictionary of terminology mappings. A draft of the UMLS representation of miliary tuberculosis appears in Figure YY.

In contrast to UMLS, the Medical Subject Headings of the National Library of Medicine (MeSH), is a thesaurus of medical terminology which is organized withing a hierarchy according to *broader-than* and *narrower-than* terms based on links in the *is-a* class. Although MeSH was developed as a means of classifying bibliographic citations [39,40], there have been recent attempts to use MeSH as a means of acquiring information,

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UMLS Tracking Number 14300

1.	DISEASE NAME:	miliary tuberculosis
	Alternate Names:	disseminated tuberculosis
	MeSH Name:	tuberculosis miliary
	MeSH #:	
	ICD9 NAME:	miliary tuberculosis
	ICD9 #:	
	ICDO NAME:	NA
	ICDO #:	
	SNOMED NAME:	tuberculosis, miliary
	SNOMED #:	d01884d01885
	CMIT Name:	tuberculosis, miliary
	CMIT CAT-#	03-4899
	QMR Name:	hepatic miliary tuberculosis
	PDQ Name:	NA
	McKusick Number/Name:	NA
	McKusick See Also Entries NA	
	See Also Diseases	
	Exclusionary Diseases:	
2.	PREVALENCE in USA:	
	INCIDENCE in USA:	
	other Epidemiology:	
3.	PREDOMINANT SEX:	male = female
	PREDOMINANT AGE:	pediatric(3 months-16 years); young adult(16-40 years)
	PREDOMINANT Race:	black; other
4.	ETIOLOGY/PROX.CAUSE:	hematogenous dissemination of primary tuberculosis; dissemination of reactivated old tuberculosis infection
5.	GENETICS:	
6.	COMPLICATIONS:	
7.	CONSEQUENCES:	hepatic miliary tuberculosis; tuberculous meningitis; tuberculous pleurisy
8.	CONCURRENT DISORDERS:	diabetes mellitus; steroid use; lymphoma; AIDS
9.	ENDEMIC AREAS:	
10.	COURSE:	acute; chronic; intermittent
11.	SYMPTOMS(>90%):	weight loss; anorexia
	SYMPTOMS(50-90%):	recurrent fever; double quotidian fever; night sweats
	SYMPTOMS(<50%):	pleurisy; amenorrhea; dyspnea at rest; exertional dyspnea; myalgias; cough
12.	SIGNS(>90%);	
	SIGNS(50-90%):	pallor; diaphoresis; tachycardia; epididymitis; orchitis
	SIGNS(<50%):	DECR breath sounds; chest dullness to percussion; emaciation; hepatomegaly; hyperpnea; lymphadenopathy; pleural friction rub; bibasilar rales
13.	LABORATORY(>90%):	sputum; usually negative for AFB transbronchial biopsy:AFB; positive *mycobacterium tuberculosis* culture liver biopsy:AFB; positive *mycobacterium tuberculosis* culture
	LABORATORY(50-90%):	anemia; INCR ESR; monocytosis; PPD positive; hyponatremia; bone marrow biopsy; AFB; positive *mycobaterium tuberculosis* culture
	LABORATORY(<50%):	hypoalbuminemia; INCR alkaline phosphatase; PPD negative
14.	PATHOLOGY(>90%):	
	PATHOLOGY(50-90%):	bone marrow biopsy; granulomas
	PATHOLOGY(<50%):	
15.	X-RAY(>90%):	
	X-RAY(50-90%):	normal CXR
	X-RAY(<50%):	fine diffuse pulmonary nodules; ghon complex
16.	EXCLUSIONARY FACTORS:	
17.	TREATMENT:	antituberculous chemotherapy
18.	PROGNOSIS:	more likely to be fulminant in children than in adults; more likely to be fulminant in previously infected person; grave prognosis if untreated; good response to chemotherapy
19.	PREVENTION/AVOIDANCE:	BCG vaccination; treat infectious persons; chemoprophylaxis for skin test conversions
20.	REFERENCES:	harrison's 87; QMR; cecil 82

Figure YY. ULMS frame describing miliary tuberculosis. This figure was obtained from the UMLS request for proposals [36].

automatically, for use in a medical database [41].[†]

3.4. Medical Archival System (MARS) [42,43]

While many efforts are underway to represent standard medical knowledge by imposing structure an alternative approach is being taken by Vries and colleagues at the University of Pittsburgh. The Medical Archival System uses a sophisticated thesaurus of medical terminology as an interface to a large archive of medical texts including patient records and medical literature references. Athough a laboratory interface and a diagnostic engine (based on QMR), are planned as separate components of the system, the thrust of MARS is to be able to index and retrieve information from an electronic form of the patient textual record. In contrast to attempts to standardize the medical record, MARS expects to be able to store free text records with retrieval being managed using an intelligent interface. This approach of allowing data to exist in a non-structured form departs, uniquely, from the approachs of many other developers of patient care systems who require application-specific data formats, and is controversial on that basis, alone [44,45].

3.5. The American Society for Testing and Materials [46]

In November of 1980, the American Society for Testing and Materials (ASTM) established Committee E-31 in an attempt to deal with the need for a systematic approach to the computerization of laboratory testing instruments [47]. Early efforts of this committee centered on industrial analytic chemistry laboratories and emphasized guidelines and practices rather than standards but the effort quickly expanded to include many type of testing facilities. There are a number of subcommittees (some described, below), but of relevance to medical thesauri is Subcommittee E-31.12 on Medical Informatics which has been charged with the development of a standard for the representation of medical terminology. Standard E31.12.08, which wss recently approved, is not so much a thesaurus as it is a guideline for the construction of thesauri. The relationship of these other medical thesauri to E-31.12 is unclear but it seems likely that terminology differences, if they should come to exist, might be mapped between standards using a scheme such as those employed by Miller and colleagues at the University of Pittsburgh, or by Evans and Carbonell at Carnegie-Mellon University [38].

3.6. Comment

In no area of medicine are Djikstra's remarks more pertinent than in the study of medical terminology and terminological "standards". Almost every subspecialty of medicine has its peculiar vocabulary and dictionary and within a subspecialty there can be tremendous variation in the usage of terms. Two approaches have been taken to the development of these thesauri. One approach advocates the construction of databases in search of applications and would suggest that general purpose lexicons can be constructed, prospectively, in such a way that they anticipate the needs every or, at least, a majority of users. The alternative approach involves the design of thesauri geared toward specific applications (such the vocabularies of HELP and INTERNIST-1). Ofentimes the latter are not easily decomposed into generally useful thesauri without extreme effort and frequent human intervention [38].

One danger to adopting a standard for terminology is that forced compliance is rarely, if ever, successful. For example, CPT-4 codes and the Veteran's Administration core data dictionary were accepted because they were designed by the users to answer particular information needs (in the case of the former, it was simplification of insurance forms). In contrast, other efforts have had no success (such as the recommendations of the Korner

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[†] MeSH headings are also used, in concert with a number of other techniques, as a method of extracting data from the literature for use in the QMR medical knowledgebase, in a project at the University of Pittsburgh, head-

Committee in the United Kingdom), or limited success (such as SNOMED), because they have attempted to impose terminology on the user without a consensus of opinion as to the representation of information. Finally there is the very practical concern of educating the user as to the appropriate use of the terminology. It should be remembered that while continuing education is an almost a universal requirement for recertification in a health field, experience shows that acceptance of a new terminology is a slow process which all too often introduces new ambiguities instead of alleviating old ones.

Clearly it is too early to tell which, if any, of these will become truly useful standards; it seems likely that a least a few, and some newer ones as well, were persist for many years to come. For the purposes of MEDIX, a reasonable approach which would obviate the need to adopt a terminology standard at this time would be to define a series of transactions which would allow systems to negotiate which lexicon to use for subseqent transactions. Presumably, multiple dictionaries could be supported with relative ease until such time (if ever), that a true standard appears.

4. Message Protocols and Hardware Interfaces

In addition to those efforts to standardize medical terminology are those efforts to characterize and standardize those processes which involve the transfer of information from one patient-care actor to another. Most of these focus on the definition of atomic units of information called *messages* or *transactions*, which can be passed between various information systems and to users of those systems. In defining a message a number of factors are considered For example, a message should be discrete and self-contained, so that accurate information transfer is not dependent on the contents of a previous or subsequent message. This provides some protection against a failure of one of the participants to send or receive a message resulting in a loss of information. Since one impetus for the design of message systems is the increasing use of computer technology in medical care, messages are designed to conform to standards for the transfer of information between information systems. These include the standards set forth by the International Organization for Standardization (ISO) known as the Open Systems Interconnect (OSI).

OSI is a seven-layered protocol for host-to-host communication described, elsewhere, in detail. A *host* may be any kind of information processing device or terminal. Each of the six upper layers is built only on the layer below. The lowest layer, the *physical layer*, defines a protocol for the hardware connection, such as ETHERNET or STARLAN. The highest layer, the *application layer* specifies the standard set of routines on which an application may be built. The advantage of adhering to ISO standards is the fact that ISO has been accepted and will be supported by all of the major vendors of hardware and software systems in the future. Most of the efforts, described below, are at the ISO applications level.

4.1. Transfer Data [48]

In 1983, the Commission on World Standards of the World Association of Societies of Pathology (called the *COWS of WASP*), organized an international symposium in order to draft a proposal for transfer standard for electronic medical laboratory data. The purpose of this standard was to allow for the rapid exchange of medical data in a format which would be universal across all written and spoken languages. Because the symposium took place in three separate sessions (Berlin, Tokyo, and St. Louis), the standard specification has come to be known as BTL-83. Like the ASTM standard, BTL-83 chose to use existing specifications for data wherever international standards existed; SNOMED names are used to specify specimen type and body site; ISO standards are used to express date, time, units of measurement, and country of origin codes; the Institute for Standardization and

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ed by Nunzia Bettinsoli Giuse, M.D.

Documentation in Medical Laboratories (INSTAND) standards are used to specify instrumentation and reagents.

4.2. ASTM Committee E-31 [49]

In addition to Subcommittee E-31.12 on Medical Informatics there exists a number of other ASTM Subcommittees many of which deal with the nature of messages passed between health care systems [46]. Subcommittee E-31.03 Automated Patient Care Information System is concerned with transactions which characterize the Admission-Discharge-Transfer (ADT), unit of a hospital-based system. The Hospital Pharmacy Computerization Subcommittee (E-31.10), and the Clinical Laboratory Systems Subcommittee (E-31.13), deal with patient medication and laboratory data, respectively. The Clinical Laboratory Instrument Interface is pursuing a course similar to that taken by the IEEE Medical Information Bus Committee for hardware interface standards for medical laboratory devices.

In January of 1988, ASTM Subcommittee E-31.11 published DRAFT Version 1.0 of a ***Standard Specification for Transferring Clinical Laboratory Data Messages Between Independent Computer Systems.*** **As specified in the Scope of this document:**

> This standard covers the two-way digital transmission of laboratory requests and results among remote laboratories and medical offices or hospital computers. It is intended to document the common conventions required for the interchange of laboratory results and patient data between laboratory information systems and other systems supporting patient care. The Standard specifies a logical format for sending requests for laboratory services to, an receiving results from, a laboratory computer. It enables any two systems to establish a link for communicating text to send result or request information in a standard and interpretable form. It deals not only with general information about laboratory testing, but specific details useful for clinical practice, administration and research in a comprehensive, but flexible convention.

The model for the clinical laboratory standard is a two-way message passing system for the exchange of data between systems. A format is specified for these messages which have subdivisions or ***fields*** **separated by delimiters. In order to avoid constraining the amount of information contained in a single message, it was determined that fields of variable (but maximum), length be supported. In addition, it was the intention of the ASTM Subcommittee that existing standards, wherever applicable, be adhered to in the design of E-31.11. In particular:**

- **all data is expressed in a restricted form of the ASCII character set**
- **field delimiters are, likewise, ASCII characters**
- **units are represented in the ANSI (ISO-5218 1977) standard format**
- **dates are represented in the ANS X3.30-1985 standard format**
- **times are represented in the ANS X3.43-1986 standard format**
- **a** ***Universal Test Identifier*** **field specifying the test context of the message is based on the AMA CPT-4 test codes**
- **the** ***Analytical Methods*** **and** ***Laboratory Instrumentation*** **fields use descriptors as specified by the INSTAND Scheme [48].**
- **reagents are specified according to American Chemical Society nomenclature**
- **organisms are specified according to the Manual of Clinical Microbiology [50]**
- **diagnosis codes are specified according to ICD9-CM**
- **the message content will conform to the ISO standards for Layer 7 of the Open Systems Interconnect (OSI) Model.**

The need for an ASCII data representation scheme is motivated by the concern for interfacing the office clinician with the laboratory. Since communication will, most likely, be via modem over a phone line, ASCII transactions were felt to be most resistant to corruption and error. In this way, the scope of ASTM differs, somewhat, from that of MEDIX (described, below).

In addition to Subcommittee E-31.11, there exists a Subcommittee E-31.12 chartered to develop a standard for medical nomenclature. The relationship of that standard to other nomenclature standards is unknown.

4.3. The ACR/NEMA Radiology Record [51]

In the area of radiology the American College of Radiology (ACR) and the National Electrical Manufacturer's Association (NEMA) are sponsoring a joint effort to develop a interface standard for communication between radiologic devices and picture archiving (PACS) systems based on the ISO Reference Model for open systems known as Open Systems Interconnect (OSI). OSI implementations already exist for the lower layers of the seven-layer protocol (Appendix 2), and a number of manufacturers are working on upper layer implementations to be used in various computing environments including those commonly found in hospital settings.

4.4. IEEE Standards [52]

The Institute of Electrical and Electronics Engineers (IEEE) Engineering and Medical Biology Society has two efforts underway to develop standards for the exchange of medical information.

The Medical Information BUS (MIB), standard P1073 specifies a hardware interface designed to allow instruments used in acute care settings (vital signs monitors, pulse oxymeters, EKG), to communicate with each other and with various intelligent ICU monitoring systems available from assorted vendors. A Medical Device Data Language (MDDL), based on remote procedure call environments (examples of which include Sun RPC and Xerox Courier), specifies a communication protocol for the interaction between the various devices and computers on the network. MDDL is implemented according to the ISO Remote Operations Protocol standard which guarantees compatibility with networking environments from all major vendors of computer hardware.

In the MIB model (Figure ZZ), bedside monitoring devices interface to the network via a Device Communications Controller (DCC). Within the same bed multiple monitoring devices may exist, all of which interface to each other and the outside world via a Bedside Communications Controller (BCC). The specification for this interaction is described by the specification IEEE P1073.2. The BCC serves to facilitate the transfer of information between the local environment and the hospital unit network while isolating device specific data from the larger network. BCCs communicate with the larger network via an Inter-Bed Network (IEEE P1073.3). A number of the major manufacturers of ICU monitoring equipment have participated in the development of the MIB Proposed Standard which is in the process of preparation for balloting as a standard.

The Medical Data Interchange (MEDIX), another proposed IEEE standard, is an attempt to address the need for an electronic medical records standard by providing for a common query language to be used to exchange data between various medical databases of differing formats. The MEDIX effort is the result of an informal meeting of attendees of the 1986 MEDINFO Conference in Washington, D.C. As chartered by IEEE, the purpose of MEDIX is to:

- define a standard set of interface transactions which allow health care information systems to exchange data

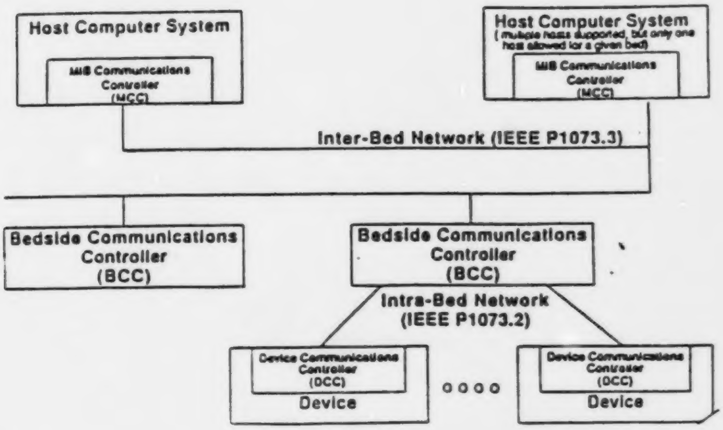

Host Computer System
MIB Communications Controller (MCC)
Host Computer System
(multiple hosts supported, but only one host allowed for a given bed)
MIB Communications Controller (MCC)
Inter-Bed Network (IEEE P1073.3)
Bedside Communications Controller (BCC)
Bedside Communications Controller (BCC)
Intra-Bed Network (IEEE P1073.2)
Device Communications Controller (DCC)
Device
oooo
Device Communications Controller (DCC)
Device

Figure ZZ. Medical Information Bus

- support communications among patient care settings and ancillary services including both inter- and intra- hospital communication
- maintain the integrity of the standard by insuring that successive versions remain compatible
- structure the standard in such a way as to allow multiple subsets of features to co-exist
- maintain compatibility with the ISO Applications Service Element so that data can be exchanged between MEDIX and non-MEDIX hosts through a common protocol
- provide a framework for allowing the migration of applicable health care standards into a common reference model
- preserve integrity, consistency, reliability, security, and ownership
- specify the representation of data primitives as well as data types
- not assume a particular decomposition of the health care system into subsystems

4.5. Comments

In the case of MEDIX, what is proposed is a standard for modelling transactions betweens *actors in a health care setting. Although what is envisioned is host-to-host communication, these actors* might, in fact, be clinicians, health care workers, desktop workstations or patient information systems. Agreement on the type and form of these transactions would allow individual vendors to utilize the common exchange format while preserving their internal representation formats. As it exists in its current form, MEDIX is geared toward the exchange of data obtained from mixed sources, in particular, the clinical laboratory, ADT, pharmacy management, and financial management.

The success of the MEDIX effort will depend upon vendor acceptance and user acceptance. This, in turn, will depend upon the extent to which the vendors' and users' needs are satisfied. A reasonable first approach has already been taken, namely, to survey existing systems as a starting point for future developments, but in addition, user needs must include a consideration of those interests which are not, yet, served by information systems. It is arguable whether the entire spectrum of user needs can adequately be defined within

the constraints of the MEDIX structure. It will be, perhaps, left to vendors and the appropriate Federal agencies to fund the necessary protocol and discourse analyses which may give the only truly complete description of user needs as characterized by their day-to-day activities.

1. **R. S. Patil, P. Szolovits and W. B. Schwartz, "Modelling knowledge of the patient in acid-base and electrolyte disorders", in *Artificial Intelligence in Medicine*, vol. AAAS Selected Symposium 51 , P. Szolovits (editor), Boulder Colorado, 1982, Westview Press.**
2. **W. V. Slack, "The soul of a new system", *Massachusetts Medicine*, November/December, 1987, 24-28.**
3. **C. S. Gadd and H. E. Pople, "An interpretation synthesis model of medical teaching rounds discourse: implications for expert system interaction", *International Journal of Education Research*, Special Issue on the Use of Computer Simulation as Research Tools 1, *1 (1987).***
4. **C. S. Gadd and H. E. Pople, "Evidence from internal medicine teaching rounds of the multiple roles of diagnosis in the transmission and testing of medical expertise", in *Diagnostic Monitoring of Skill and Knowledge Acquisition* (forthcoming), *N. Frederiksen (editor).***
5. **M. M. Lacks and J. T. Niemann, "Computer linkage of the clinical history to electrocardiographic language (ECL) premitting the use of Bayes' Theorem", *Proceedings of the 11th Conference on Computers in Cardiology*, Washington, D. C., October 7-10, 1986, 537-540.**
6. **L. E. Ginzton and M. M. Lacks, "The use of computer programs for the development and validation of electrocardiographic criteria", *Proceedings of the 6th Conference on Computers in Cardiology*, Washington, D. C., October 7-10, 1986, 405-408.**
7. **G. O. Barnett, N. S. Justice, M. E. Somand, J. B. Adams, B. D. Waxman, P. D. Beaman, M. S. Parent, F. R. Van Deusen and J. K. Greenlie, "COSTAR - A computer-based medical information system for ambulatory care", *Proceedings of the IEEE 67* (1979), 1226-1237.**
8. **G. O. Barnett, "The application of computer-based medical-record systems in ambulatory practice", *The New England Journal of Medicine 310*, 25 (June 21, 1984), 1643-1650.**
9. **J. Bowie and G. O. Barnett, "MUMPS - an economical and efficient time-sharing system for information management", *Computer Programs in Biomedicine 6*, 1 , 11-22, North Holland Publishing Company.**
10. **L. L. Weed, "Medical records that guide and teach", *New England Journal of Medicine 278*, 11 (March 14, 1968), 593-600.**
11. **L. L. Weed, "Medical records that guide and teach (concluded)", *New England Journal of Medicine 278*, 12 (March 21, 1968), 652-657.**
12. **L. L. Weed and R. Y. Hertzberg, "The use and construction of problem-knowledge couplers, the knowledge coupler editor, knowledge networks, and the problem-oriented medical record for the microcomputer", in *Proceedings of the Seventh Annual Symposium on Computer Applications in Medical Care*, IEEE Computer Society Press, Silver Spring, MD, October 23-26, 1982, 831-836.**
13. **J. R. Schultz and L. Davis, "The technology of PROMIS", *Proceedings of the IEEE 67*, 9 (1979), 1237-1244.**
14. **"Automation of the problem-oriented medical record PROMIS laboratory", *National Center for Health Services Research Digest Series*, 1977.**

15. J. F. Fries, "Time-oriented patient records and a computer databank", *Journal of the American Medical Association 222*, 12 (December 18, 1972), 1536-1542.

16. J. F. Fries and D. J. McShane, "ARAMIS: A national chronic disease data bank system", *Proceedings of the Third Annual Symposium on Computer Applications in Medical Care*, Washington, D.C., November, 1979, 798-801.

17. W. E. Hammond II, W. W. Stead, M. J. Straube and W. E. Hammond III, "Adapting to the day to day growth of TMR", *Proceedings in the Seventh Annual Symposium on Computer Applications in Medical Care*, 1983, 101-109.

18. W. E. Hammond and W. W. Stead, "Functions required to allow TMR to support the information requirements of a hospital", in *Proceedings in the Seventh Annual Symposium on Computer Applications in Medical Care*, R. E. Dayhoff (editor), IEEE Computer Society, Los Angeles, CA, 1983, 106-109.

19. S. R. Kozel, "Is computerization worth the price? An evaluation of 7 years' use of TMR", in *Proceedings in the Seventh Annual Symposium on Computer Applications in Medical Care*, R. E. Dayhoff (editor), IEEE Computer Society, Los Angeles, CA, 1983, 110-115.

20. W. E. Hammond, W. W. Stead, M. J. Straube and M. Lutz, "TMR meeting the demand for the variety of report modalities", in *Proceedings in the Eighth Annual Symposium on Computer Applications in Medical Care*, G. S. Cohen (editor), IEEE Computer Society, Los Angeles, CA, 1984, 421-424.

21. C. J. McDonald, L. Blevins, T. Glazener, J. Haas, L. Lemmon and J. Meeks-Johnson, "Data base management, feedback control and the Regenstrief medical record", *Journal of Medical Systems 7* (1983), 111-124.

22. S. G. Tolchin, E. S. Bergan, M. Arseniev, P. Kuzmak, R. Nordquist and D. Siegel, "Transaction processing using remote procedure calls (RPC) for a heterogeneous distributed clinical information system", in *Proceedings of the Tenth Annual Symposium on Computer Applications in Medical Care*, H. F. Orthner (editor), IEEE Computer Society Press, Washington, D.C., October 25-26, 1986.

23. S. G. Tolchin, E. S. Bergan, M. Arseniev, P. Kuzmak, R. Nordquist and D. Siegel, "Transaction processing using remote procedure calls (RPC) for a heterogeneous distributed clinical information system", *Computer Methods and Programs in Biomedicine 25* (1987), 193-208.

24. P. M. Kuzmak, S. N. Cahane, M. Arseniev, S. G. Tolchin and R. E. Lehnard, "The role and design of an integrated clinical result database within a client-server networked hospital information system architecture", *Proceedings of the Eleventh Annual Symposium on Computer Applications in Medical Care*, Los Angeles, California, 1987, 789-795.

25. M. R. Ostler, D. Stansfield and A. Pryor, "A new, efficient version of HELP", in *Proceedings in the Ninth Annual Symposium on Computer Applications in Medical Care*, M. J. Ackerman (editor), IEEE Computer Society, Los Angeles, CA, 1985, 296-297.

26. H. R. Warner, C. M. Olmsted and B. D. Rutherford, "HELP - a program for medical decision-making", *Computers and Biomedical Research 5*, 1 (February, 1972), 65-74.

27. H. R. Warner, "Knowledge sectors for the logical processing of patient data in the HELP system", *Proceedings of the Second Annual Symposium on Computer Applications in Medical Care*, Washington, D.C., November, 1978, 401-409.

28. R. A. Cote, ed., *SNOMED: Systematized Nomenclature of Medicine*, College of American Pathologists, Skokie, Illinois, second edition 1979.

29. F. Wingert, "An indexing system for SNOMED", *Methods of Information in Medicine 25*, 1 (January, 1986).

30. F. Wingert, "Automated indexing of SNOMED statements into ICD", *Methods of Information in Medicine 26*, 3 (July, 1987).

31. C. M. Fanta, A. J. Finkel, C. G. Kirschner and M. A. Kosche, eds., *CPT-1987: Physician's Current Procedural Terminology Fourth Edition*, American Medical Association, Chicago, July 1987.

32. A. J. Finkel, B. L. Gordon, M. R. Baker and C. M. Fanta, eds., *CMIT: Current Medical Information and Terminology Fifth Edition*, American Medical Association, Chicago, October, 1980.

33. R. A. Miller, "From automated medical records to expert system knowledge bases: common problems in representing and processing patient data", *Topics in Health Record Management 7*, 3 (March 1987), 23-35, Aspen Publication.

34. in *Medical Subject Headings*, National Libarary of Medicine Medical Subject Headings Section, 1985.

35. J. A. Hupp, J. J. Cimino, E. P. Hoffer, H. J. Lowe and G. O. Barnett, "DXplain - A computer-based diagnostic knowledge base", *MEDINFO 86: Proceedings of the Fifth Conference on Medical Informatics 5* (October 26-30, 1986), 117-121, North Holland.

36. R. A. Miller and F. E. Masarie, Jr., editors. "Mapping of Medical Knowledge Representations: INTERNIST-1, HELP, and MeSH", Final Task Report NLM Contract No. N01-LM-6-3522, National Library of Medicine, Bethesda, Maryland, April 10, 1987.

37. C. H. Claudon, Jr. and F. E. Masarie, Jr., "UMLS Medical Diagnostic Concept Frame System: Instantiated Frame Editor Module Version 2.01", Department of Medicine, Section on Medical Informatics, University of Pittsburgh, Pittsburgh, Pennsylvania, October 19, 1987.

38. D. E. Evans, "Final Report on the Medsort-II Project", CMU, Carnegie-Mellon University, Pittsburgh, Pennsylvania, August, 1987. Laboratory for Computational Linguistics.

39. D. B. McCard, "MEDLINE: an introduction to on-line searching", *Journal of the American Society of Information Science 31* (1980), 181-192.

40. *MEDLARS: the Computerized Literature Retrieval Service DHEW NIH 79-1286* (1979), National Library of Medicine.

41. S. Lester and R. Rada, "A method of medical knowledge base augmentation", *Methods of Information in Medicine 26*, 1 (January, 1987), 31-39.

42. G. D. Carlos, J. K. Vries and P. Shoval, "Construction of a thesaurus for medical knowledge", in *Proceedings of the Ninth National Online Meeting*, Learned Information, Medford, New Jersey, *in press*.

43. J. K. Vries, P. Shoval, D. A. Evans, J. Moossy, G. Banks and R. Latchaw, "An Expert System for Indexing and Retrieving Medical Information", Decision Systems Laboratory Technical Report, University of Pittsburgh, Pittsburgh, Pennsylvania, August, 1986. 1360 Scaife Hall, Pittsburgh, Pennsylvania 15261.

44. J. Andersen, "Data dictionaries - A way forward to write meaning and terminology intommedical information systems", *Methods of Information in Medicine 25*, 3 (July, 1986), 137-138.

45. J. R. Mohr, "The generation of generations", *Methods of Information in Medicine 25*, 2 (1985).

46. F. R. Jelovsek, "AAMSI: state of the association address", *MD Computing 5*, 1 (January/February 1988), 14-15.

47. J. W. Frazer and F. W. Kunz, eds., *Symposium on Computerized Laboratory Systems*, American Society for Testing and Materials, Philadelphia, March 4-5, 1974.

48. F. R. Elevitch and K. Boroviczeny, "Transfer data: a proposed international standard for interlaboratory information exchange", *Archives of Pathology and Laboratory Medicine 109* (June, 1985), 496-498.

49. C. E. McDOnald, "Standard specification for transferring clinical laboratory data messages between independent computer systems", ASTM Subcommittee E-31.11, American Society for Testing and Materials, Philadephia, January 8, 1988. DRAFT Version 1.0.

50. E. H. Lennett, A. Balows, W. J. Hausler Jr. and H. J. Shadomy, eds., *Manual of Clinical Microbiology*, American Society of Microbiology, Washington, D.C., 1985.

51. A. D. A. Massar, J. P. J. Valk, G. L. Reijns and A. R. Bakker, "Simulation of an image network in medical image information system", *Proceedings of the International Symposium on Computer Assisted Radiology 593* (1985), 123-131 , ANRT (Association Nationale de la Recherche Technique).

52. T. E. Rutt, "IEEE EMBS standards work - MIB and MEDIX", in *Proceedings of the AAMSI Conference (to appear)*, American Association for Medical Systems and Informatics, Washington, D.C., May 4-6, 1988.

APPENDIX L

PROPOSAL FOR A MAJOR NRC INITIATIVE

PROPOSAL FOR A MAJOR NRC INITIATIVE

1. **TITLE:** Technologies for the Containment of Costs in Health Care Delivery

2. EXECUTIVE SUMMARY:

This paper proposes an NRC-led National Program for the development and use of technologies targeted to the containment of costs in health care delivery, the Program to involve laboratories and health care practitioners across the country and to be phased in to reach a budget level of $200 million per annum. In effect, 10% of the estimated unchecked growth in health care costs would be utilized to prevent such growth.

The health care sector in Canada is approaching a critical stage due to expanding demand and emerging limits to funding. Various cost containment approaches are being tried in the health sector including new fee structures, new management methods and limits to the number of hospital beds and to the number of doctors eligible to bill under current schemes. Most of these approaches tend to limit access to health care. Moreover, much current technology development in the sector tends to add to the quality and sophistication of health care with relatively little emphasis on cost reduction.

Therefore, a parallel emphasis on technologies for cost containment without compromising quality is both socially acceptable and timely. Indeed, considerable opportunities exist for new technologies directed to the care and monitoring of patients outside the expensive hospital environment.

The likely technical and financial collaborators are many. It requires leadership from a federal agency such as NRC to coordinate a national effort directed to cost containment technologies.

The NRC proposal contains (a) management components including an Advisory Board of NRC's Council and (b) laboratory components, including a significant NRC laboratory component. The proposal also includes an emphasis on economic opportunity for the private sector.

The anticipated benefits, which are the program objectives, would be cost savings due to cost containment of up to $2 billion per annum compounded and industrial growth reaching $500 million p.a. in new sales (including exports) and 5000 new industrial jobs.

PROPOSAL FOR A MAJOR NRC INITIATIVE

1. **TITLE:** Technologies for Containment of Costs in Health Care Delivery

2. **PREFACE:** The Canadian health care system is headed for a crisis because of rising costs and limits to financial resources. Many of the attempted solutions to this problem are socially unacceptable because they limit either the access to, or the quality of, health care services.

Improved technology is probably the most socially acceptable tool for moderating growth in health care expenditures by contributing to increased cost effectiveness of the system. However, technological solutions are not effective in isolation but must be compatible with the human component of the health care system. Also, care givers must be trained and supported to more efficiently apply new technology in the delivery of health care.

The emphasis of this proposed initiative is on a major national technology program; but linkages forged with other agencies and organizations (see Section 12) will focus on the necessity of assuring that there will be an infrastructure which will implement and support the technology to moderate the growth of health care expenditures.

3. **OBJECTIVES:** This initiative would result in:

a) development, importation and application of technologies for cost containment

These technologies would provide useful options for containing the costs of both chronic and acute care while maintaining the effectiveness of health care delivery.

b) industrial development and economic growth

Business opportunities based on technologies for containing health care costs would stimulate Canadian companies to produce new products and services and create new wealth and employment.

4. OVERVIEW:

a) Health Care Costs:

Annual expenditures in the Canadian health care sector are approaching $35 billion and are increasing at a rate of at least 5% per year in constant dollars. This sector involves all levels of government plus numerous institutions, health care professionals, support staff, scientists, engineers, academics, manufacturers and suppliers, all of whom have particular interests. To the extent that these groups are concerned with the application of technology, the emphasis is usually on improving the quality of health care. This has led to the development in Canada of one of the best health care systems in the world, but there is increasing concern about the growing percent of the national wealth consumed in health care.

The proposed initiative will raise a parallel emphasis to that on quality, namely cost containment. Without such an emphasis the nation's ability to deliver excellent health care will diminish because of (i) increasing costs per patient and (ii) increasing numbers of patients from the growing population of Canadian elderly who are the major consumers of health services. It is expected that the proposed initiative will help provide for the growth in demand with maintenance of high quality by helping the health sector workforce do more, without threat to jobs in the sector.

b) Industrial Development:

There are over 400 Canadian companies currently involved in the manufacture and distribution of health care products. In addition, an increasing number of Canadian high technology companies are looking to the health care market as an area to apply their expertise and thus sustain their growth. Industrial and technological growth in this sector is hampered through a lack of awareness by many Canadian companies of which are the most promising products and services to produce and where the expertise or technology to develop these markets may be found.

This proposed initiative will involve market considerations to channel technological research and development activities in Canada and screen foreign technology for addressing the cost containment problem. The most promising technologies will be linked with suitable Canadian companies for commercialization and job creation in Canada.

5. STRATEGIES:

a) Cost Containment:

A number of financial and management strategies have been tried to contain health care costs including new pricing and patient management strategies, privatization of hospital management and the imposition of limits on the number of beds in hospitals and the number of doctors eligible to bill under provincial health plans. Nevertheless, better technology is probably the most powerful and socially acceptable tool for containing health care costs in the long term.

Within the framework of the technological approach there are two main paths for reducing costs: increasing the cost effectiveness of human resources in institutional care and decreasing the rate of institutionalization. (Note that drugs and appliances represent only 12% of the cost of health care while almost 80% is attributable to labour costs). Therefore, the proposed initiative will focus on (i) reliable, easily serviceable medical devices and systems for helping labour in institutions and (ii) technologies which would increase patient mobility, enhance self care of the elderly, reduce hospital stay and expand possibilities for home care. Selection and development of these technologies will be done with the consultation and help of health care practitioners to ensure market needs are addressed and champions for implementation are found. Projects and technologies that qualify for support under the proposed initiative would be selected for their cost containment potential by reference to a comprehensive integrated set of cost models developed under the Program.

b) Industrial Development:

In 1981, Canada spent $1.2 billion on medical devices (almost 80% imported) and this market has grown at an annual rate of 11%. It is clear that there are tremendous business opportunities for Canadian companies in the health care sector. The proposed initiative will focus on small and medium size Canadian companies. It will channel their activities by helping them identify and commercialize technology-based opportunities that lead to health cost containment and create jobs. These opportunities may arise from Canadian or foreign research and from either biomedically dedicated research or research in other fields. Historically, some of the greatest impacts on the health care system have come from the application of technology not initially developed for use in health care. Therefore, the initiative will develop a strong capability for identifying and assessing opportunities by building a special component into NRC's technology transfer network that specifically deals with screening technology for applications in containment of health care costs.

6. GLOBAL HEALTH RELATED TECHNOLOGY DEVELOPMENT:

Health related research and development as distinct from health care itself is a massive global endeavour representing about $15 billion per annum and 500,000 person years in 1980. The Canadian share of this total is just over 2%.

An important question is how effectively Canada can engage this global research machine in the cause of containing Canadian health care costs and stimulating Canadian industry, given available resources.

7. CANADIAN ACTIVITIES IN DEVELOPING HEALTH RELATED TECHNOLOGIES:

In 1986/87 the Reference List of Health Science Research in Canada listed over 8,000 research projects supported by 47 public sector agencies and nonprofit foundations at a total cost of over $300 million. Over 200 projects were identified in the (Canadian) Inventory of Projects in Bioengineering (1985) covering electrophysiology, rehabilitation, diagnostic devices, orthopedic devices and representing public sector grants of over $12 million. The vast majority of these projects were carried out at academic institutions or their affiliates and only a few had linkages to Canadian industry.

The industrial sector accounted for approximately 12% of the total spent on Canadian biomedical research and development in 1980. This compares unfavourably with the average of 36% in other developed countries and reflects the relative weakness of this sector in Canada and the need to stimulate it.

8. RELATED NRC ACTIVITIES:

The existing NRC effort parallels the national and international activities in health care research: one part of NRC is dedicated to biomedical research while other parts are active in other fields developing technologies which may also find application in health care delivery. The NRC effort is large enough to provide an effective window on what is happening technologically both nationally and internationally and to apply this to solving specific problems. A notable NRC achievement in the recent past was the development of the first cardiac pacemaker. The part of NRC dedicated to biomedical research has focussed its activities in five areas: (see Appendix A).

(i) Habilitation/Rehabilitation

(ii) Medical Devices

(iii) Non-invasive Diagnostics and Therapeutics

(iv) Immuno-chemistry

(v) Disease Mechanisms and Biological Processes

The activity also includes Associate Committees such as the Associate Committee on Research and Development for Rehabilitation of Disabled Persons which has recently developed a proposal for a Rehabilitation Science Institute.
NRC's biomedical research is multidisciplinary and is conducted with external collaborators, both clinical and industrial. In some cases, such as products for rehabilitation, NRC has a special lead role in promoting commercialization through its Rehabilitation Technology Unit.

In addition, the Industry Development Office of NRC has supported industrial research and product development in the areas of disease prevention, diagnosis and treatment as well as rehabilitation. This effort has been coupled with international technology identification in these areas for the purpose of increasing the business opportunities available to Canadian industry.

The current biomedical activities of NRC provide a good base from which to pursue the proposed health care cost containment initiative.

9. A PROGRAM FOR HEALTH CARE COST CONTAINMENT:

What is needed is a Program to

(i) contain the costs of both chronic and acute care while stimulating industrial development;

(ii) develop a comprehensive cost model for the health care system which takes into account all costs to the public (in some cases including welfare costs) and which analyses both chronic and acute care costs so the claim of cost saving for a new technology can be tested and verified;

(iii) channel research efforts in both the biomedical and nonbiomedical streams toward nationally and internationally identifying technologies for containing health care costs;

(iv) link this technology identification effort with Canadian industrial development through a rapid and efficient technology transfer assistance network so these technologies can be quickly brought to market and thus exert their effect on controlling health care costs

(v) promote demonstration of and acceptance for the most promising new products and services aimed at cost containment.

It is evident that the lead in developing this Program should come from the public sector because of the very large number of agencies and organizations which would necessarily be involved. Indeed, the effort would be as much in developing consensus and collaboration as in developing technology. Another advantage of public sector leadership would be the ability to foster technologies which have a strong effect in controlling costs but which may not maximize profits for the private sector although being implementable in other ways.

10. NATIONAL VERSUS PROVINCIAL PROGRAM.

A national collaborative program would be more effective than ten provincial cost containment programs. Canada's health care system is administered by the provinces but is national in scope because the aim is to maintain the same standards of health care delivery in all regions of the country. Similarly, a program aimed at containing health care costs must have a national focus to ensure that the resulting benefits are made available for application in all regions of the country. A national program would be better placed to capitalize on existing technologies and human resources anywhere in Canada and outside, so that the best research teams may be coupled with the most appropriate Canadian companies to commercialize technology for containing health care costs.

11. FEDERAL LEADERSHIP OF A NATIONAL PROGRAM:

Responsibility for support, development and linkage to the health care industry of relevant research falls across a number of government departments, federal, provincial and municipal. There are gaps between departmental mandates which often mean that projects miss their windows of opportunity through delays or stoppage of technical and financial support. This is particularly damaging to the growth of the small medical devices industry in Canada. Therefore, it clearly is desirable that managing the activities of such a National Program should be the responsibility of a single federal agency.

This lead agency must not only have a biomedically dedicated research effort but also a broad research effort in other fields so it can assess all possible cost containment technologies and technically support their development. It must have strong links with both the academic and industrial communities in Canada and links to foreign sources of technology. Finally, it must have established credibility in managing the overall process from identifying technology based opportunities to supporting companies in commercializing these opportunities.

Health and Welfare, the Medical Research Council, the Natural Sciences and Engineering Research Council and the Ministry of State for Science and Technology have links to industry which are too weak or indirect to accomplish the industrial development objective of the Program. The Department of Regional Industrial Expansion has too little direct experience in all the technologies in question to accurately judge which have the most practical potential for containing health care costs. NRC is therefore the only agency with a broad enough mandate and sufficient expertise to lead such a National Program.

12. PROPOSED NRC - LED NATIONAL PROGRAM:

This National Program would have two main components. A management component would drive the whole process by building national consensus, setting priorities and approving support for projects. A laboratory component would help identify opportunities, propose projects, carry out projects and provide technical assistance generally. Collaboration will be a fundamental characteristic of the National Program because so many other groups have research resources and interests in health care delivery and associated costs. This must be reflected in the program management structure which must permit reaching across disciplines in NRC as well as outside NRC and outside Canada.

a) Advisory Board
There will be a National Health Technology Advisory Board of NRC Council which will provide general direction and set program priorities.

Provinces

The Board members will be drawn from outside NRC. Half of its membership will be drawn from industry while the other half will be drawn from those involved in health related research, in health care delivery or in consumer groups. The Board would also appoint an Advisory Committee to coordinate provincial government collaboration and a Technology Resources Committee to coordinate the activities of the principal collaborating research organizations. To improve communications within the regions, the Board would develop regional chapters supported by local IRAP offices much as is done in NRC's Canadian Construction Research Board. These chapters will convey the results of their discussions to the Chairman of the Board.

b) Program Office

A program office, the NRC Office of Technology for Health Cost Containment, staffed by NRC employees, will make the operational decisions in the Program and administer the Program budget. The Office will set-up and manage the network required for identifying suitable technology, assessing it and supporting its development by industry for containing health care costs. The Office will utilize the IRAP Technology Transfer Network and the IRAP Project Selection Committee (augmented by members from the Medical Research Council and the National Health Research and Development Program) to identify, assess and approve projects. To that end, the Office will make available to IRAP an annual budget for identifying Canadian and foreign technological opportunities and for supporting projects in the area of health cost containment much as is now done by MOSST in the area of biotechnology. The Office will make representations to the Medical Research Council, the National Health Research and Development Program and the Natural Sciences and Engineering Research Council to include containment of health care costs as a research priority in their programs. Finally, the Office will cooperate with National Health and Welfare to establish a federal-provincial mechanism to assist the implementation of these technologies wherever possible in Canada.

c) Laboratory Component

The laboratory component will be carried out in NRC laboratories and in the laboratories of collaborating organizations across Canada, including industry laboratories.

The NRC laboratory program will play a strong role by performing cost containment research, identifying appropriate Canadian and foreign technologies, providing scientific and technical assistance to companies and providing expertise for the evaluation of technical proposals.

The core program will be carried out in the Medical Engineering and Medical Biosciences laboratories of NRC as they exist currently. However, the launch of the proposed National Program may suggest the need for coordinating and consolidating NRC biomedical research to a greater degree.

That portion of NRC's biomedical research specifically devoted to cost containment would be supported by funds from the National Program. The rest of the biomedical program funding would come from existing NRC and other sources; however, the intention is to gradually maximize the component qualifying for cost containment funds.

Since the biomedically-dedicated research effort at NRC is just a portion of the whole Canadian effort in this field, a significant part of the National Program would involve non NRC laboratories. Such outside groups would work through IRAP to propose projects, identify promising technologies nationally and internationally and provide technical assistance to companies wishing to commercialize the cost containment technologies. Initially these groups would be supported with funds from the National Program on a project-by-project basis; however, key groups that have demonstrated excellence and leadership in their areas of specialization should be designated as NRC Associate Biomedical Laboratories. These Associate Laboratories would receive funding from the National Program for qualified research. They would be used as test sites for implementing technologies related to their expertise and as training centres contributing to effective national diffusion of proven cost containment technologies into medical practice.

It will be attractive to use the National Program in a mission oriented manner to help doctors, scientists and engineers to move on a term basis out of their usual institutions into project teams located in NRC, in academia and in industry. This will help increase the exposure of NRC and other Canadian scientists to new ideas and will help increase the chances of NRC attracting and hiring promising young scientists.

d) CISTI Component

Informatics and access to organized information will have a large impact on health care costs. CISTI currently has a health sciences data service and it is proposed that it be given additional resources from the National Program to develop an informatics capability supporting the Technology for Health Cost Containment Office in its mission.

e) Cost Model Component

Part of the program budget will be used to develop a comprehensive cost model, or an integrated set of cost models, for the health care sector. The model will be a major reference tool in selecting projects aimed at cost containment and development, improvement and use of the model will be allocated to an organization reasonably disinterested in individual project decisions.

f) "Generic" Technologies

Much of the opportunity for cost containment in health care derives from major new generic technologies having application in the economy at large. In the case of non-institutional health care, for example, automation and robotics technologies, software and computer technologies, advanced materials, new sensing elements, and the growing new fields of telemedicine and medical informatics are among those that will be drawn upon.

13. BUDGET:

a) Financial Resources

The public sector spends $35 billion annually on health care. At present, this expenditure is increasing by at least 5% in real terms compounded annually (i.e. presently $1.75 billion per year in constant dollars and increasing). If a National Program is to mount a credible attack on cost increases amounting to $1.75 billion it will need financial resources in proportion to that sum of money. The aim of the National Program will be to use each year resources equal to 10% of the annual cost increment to reduce this increment to one tenth its present size by the end of 7 years. Program performance will be subjected to a major review and assessment of future support at the end of years 3 and 5 of operation.

b) Yearly Budgets

The program will be phased in and the proposed annual budgets reflect this:

Year 1	$ 30 million
Year 2	$ 60 million
Year 3	$100 million
Year 4	$150 million
Year 5	$200 million
Subsequent years	$200 million

Except for about $100,000 during the launch period, these funds will come from a mix of federal and provincial and possibly municipal health authorities, health related welfare budgets and industrial development dollars. Preliminary discussions with certain provincial government staff indicate that appreciable funding should be possible from such sources for the proposed initiative.

Anticipated expenditures are tabulated below as a percentage of the annual budget:

	Expenditures as percent of annual budget				
Type of Expenditure	Year 1	Year 2	Year 3	Year 4	Year 5
Salaries (Prog. Office)	10	5	2.5	2.5	2.5
Operations (" ")	10	7	5	5	5
University, hospital and gov't lab projects	20	23	25	27.5	27.5
Industrial development and demonstration projects	30	35	35	40.5	42.5
Seminars and information diffusion	10	10	10	5	5
Dev. of Cost Model	10	10	10	7	5
Foreign technology acquisition	10	10	12.5	12.5	12.5
Annual budget (millions of 1987 dollars)	30	60	100	150	200

14. IMPLEMENTATION:

a) Timing

The Program will be phased in over several years. If Council approves the initiative, a pilot-scale Office of Technology for Health Cost Containment will be established and staffed with five individuals who would work to secure the necessary budget from health-care funding agencies and to establish the National Health Technology Advisory Board. This will take several months and the Program could be launched officially on 1 April 1988 assuming sufficient funds to have been obtained.

During the gestational period (i.e prior to official launch of Program) some NRC seed money (approximately $75 thousand) will be used to initiate the development of a cost model for the Canadian health care system so the cost impact of new technologies can be simulated before implementation. After the official launch of the Program, the cost model will be refined and mounted on computer as an expert system to facilitate the complex analytical process. The model will be updated on a regular basis.

The official launch of the Program will be promulgated by published notices and by information seminars given by members of the Office in key centres across Canada. These seminars will solicit the input of all interested parties as well as the submission of proposals for research, development, and industrial commercialization projects. The Medical Research Council, the National Health Research and Development Program and the Natural Sciences and Engineering Research Council will be asked to place health cost containment among their priorities for funding and to pass on any projects they feel would fit the National Program. The IRAP Field Network will be used to support the National Program as an information network and conduit for proposals.

As part of Program launch, a task force will be assembled to review the groups and institutions having special expertise in health care research and health care delivery. This information will be used to decide which groups will become Associate Laboratories of NRC, involved in technology identification, assessment, development, transfer to companies and dissemination to practitioners. Key members of these groups will become the technology experts sent on international missions or to technology expositions and scientific conferences for the purpose of identifying foreign technologies with possible application in containment of health care costs.

The overall aim of the Program launch will be to have tangible positive results by the end of year 5 of the Program. To this end the bulk of project support funds (approximately 80%) will be aimed at projects which will begin to have an impact on health care costs within 3 years. The rest of the funds will be divided evenly between projects having 5 and 10 year impact horizons.

b) Human Resources

The Office of Technology for Health Cost Containment will eventually employ 20 professionals and 10 support staff in Ottawa with a further 10 professionals placed in key teaching hospitals throughout the country. The National Advisory Board will consist of volunteers from Canadian industry, the health care professions, administrators of institutions and consumer groups. The costs of their participation will be reimbursed by the Program. The NRC Biomedical Sciences and Engineering Program will require a dynamic individual with a multidisciplinary background to lead the NRC laboratory portion of the activity.

15. BENEFITS FROM THE INITIATIVE:

a) Reduced Costs of Health Care Delivery

It is estimated that if 10% of the annual increase in health care costs was invested in a National Program on Technology for Health Cost Containment, it would result in a reduction of the annual increment in health care costs from the present 5% to 0.5% in 7 years. This is not unreasonable because the experience of NRC's industry programs is that application of developed technology for cost cutting returned over $20 of savings to the firms per program dollar expended.

b) Industrial Development and Economic Growth

If the program is successful, it is estimated that within 5 years Canadian companies will collectively achieve a $500 million increase in national and international (export) sales of health related products and services. This will translate into the creation of 5000 new private sector jobs in manufacturing and R&D.

c) Spin-offs for Third World

Many of the technologies developed and implemented under the National Program not only have potential for export to developed countries but also have potential for contributing to third world development. Any technologies which reduce the rate or duration of institutionalization for health care would help third world countries with their massive health care problems. Similarly, communications and information technologies which would increase the ability of medical experts to support nurses and paramedics in the field would greatly assist delivery of health care in countries where medical expertise is scarce and the means for transporting the sick to medical centres is often nonexistent.

16. PEOPLE CONSULTED:

Discussions have been held with representatives of at least the following:

- provincial ministries of health (6)
- provincial health insurance organizations (2)
- Workmen's Compensation Boards (2)
- university health economists (3)
- hospital administrators (1)
- individual doctors and nurses (several)
- federal departments (NH&W and DRIE)
- industry associations (CAMMD and CATA)
- private firms in the medical devices and supplies businesses (several)

There is strong consensus that (a) a National Cost Containment Program is needed, (b) substantial non-federal funds can be expected and (c) NRC is the most appropriate lead agency.

APPENDIX A

A LABORATORY PROGRAM FOR BIOMEDICAL SCIENCE AND TECHNOLOGY AT THE NATIONAL RESEARCH COUNCIL OF CANADA

1.0 INTRODUCTION

The National Research Council (NRC) has played an important role in the development of biomedical research in Canada through collaborative projects with medical researchers and medical companies. NRC's multidisciplinary nature has made it an ideal partner in such enterprises having a broad base of expertise to draw on. The basic structure of the NRC Biomedical Science and Technology program is in place within the Division of Biological Sciences and Electrical Engineering, see Figure 1. The activities are well integrated where required but have operated independently where integration was not a priority.

It is clear that although Canada has one of the best health care systems in the world, it is not prepared for the burden of an aging population and rising health care costs. Biomedical Science and Technology will play an important role in maintaining the standards of health care and quality of life. NRC must consolidate its current biomedical projects to provide a coordinate response to the crisis faced by the health care system.

The National Research Council has proposed a major new national initiative, Health Care Cost Containment, aimed at:

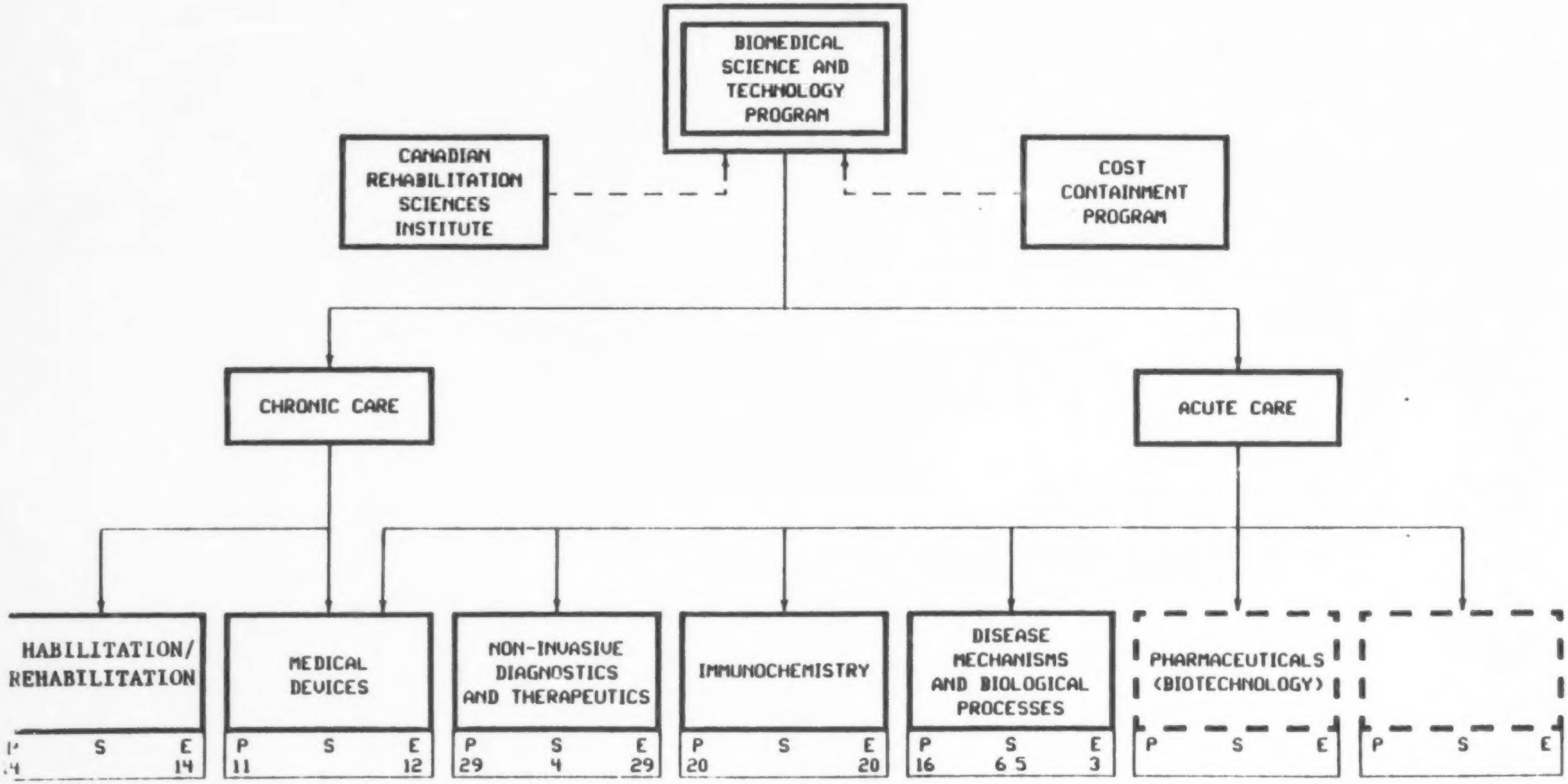
(i) reducing the rate of increase of the costs of health care by development and application of new technologies and

(ii) stimulating economic growth and new opportunities for Canadian industry

To be effective the program must draw on all sources for appropriate technologies, whether developed within Canada or abroad. One important aspect of the program will be the encouragement and support of research and development by Canadian groups. Current research activities in industry, government and universities that could improve on this initiative are fragmented and dispersed. The program will provide a process for evaluation, focussing and supporting Canadian research that can be applied to containment of health care costs.

Within National Research Council there are research activities, summarized in Table 1, that are directly relevant to those programs. There exist other projects and expertise that could contribute to the programs in various ways. The laboratories of NRC therefore, have a special role to play.

Fig.1 BIOMEDICAL SCIENCE AND TECHNOLOGY PROGRAM


BIOMEDICAL SCIENCE AND TECHNOLOGY PROGRAM
CANADIAN REHABILITATION SCIENCES INSTITUTE
COST CONTAINMENT PROGRAM
CHRONIC CARE
ACUTE CARE
HABILITATION/ REHABILITATION
P S E
4 14
MEDICAL DEVICES
P S E
11 12
NON-INVASIVE DIAGNOSTICS AND THERAPEUTICS
P S E
29 4 29
IMMUNOCHEMISTRY
P S E
20 20
DISEASE MECHANISMS AND BIOLOGICAL PROCESSES
P S E
16 65 3
PHARMACEUTICALS (BIOTECHNOLOGY)
P S E
P S E

- (Primary) NRC staff dedicated to the program

- (Secondary) NRC staff collaborating on tactical projects

(External) Non-NRC collaborators

Table 1: Existing NRC Laboratory Programs in Biomedical Science and Technology

	PY	SAL ($K)	OP ($K)	CAP ($K)	TOTAL ($K)
Habilitation/Rehabilitation					
Rehabilitation (DEE)	6	300	65	25	
Product Engineering (DEE)	7	350	106	25	
Support (DEE)	1	50	-	-	
	14	700	171	50	921
Medical Devices					
Non-Ionizing Radiation (DEE)	5	250	45	25	
Biological Information Enhancement (DEE)	5	250	45	25	
Support (DEE)	1	50	-	-	
	11	550	90	50	690
Non-Invasive Diagnostics & Therapeutics					
Molecular Biophysics (DBS) (DEE)	14	700	75	78	
Cellular Oncology (DBS)	15	750	127	46	
	29	1450	202	124	1776
Immunochemistry					
Immunochemistry (DBS)	19	950	161	49	
Fermentation Facility (DBS)	1	50	10	10	
	20	1000	171	59	1230
Disease Mechanisms & Biological Processes					
Animal Physiology (DBS)	8	400	39	49	
Animal Facility (DBS)	8	400	171	36	
	16	800	210	85	1095
TOTAL	80	4500	844	368	5712

Cost containment is a critical component in the effort to continue to provide Canadians with affordable, acceptable health care. It also provides an opportunity to bring the elements of the Laboratory program more closely together, sharpen their focus, and introduce new funding directed specifically at cost containment objectives. It is, however, not the only component. Equally important is the need to continue to maintain and improve our quality of life by finding ways to extend lifespan, reduce illness, and increase independence. The laboratory programs within NRC can and must help address this concern as well.

2.0 PROGRAM OBJECTIVES

The Biomedical Science and Technology Program basic objectives for acute care, chronic care and industrial sector of the health care industry are:

Acute care

- To determine methods for the prevention of diseases and disabling conditions.
- To reduce the demand for and stay in acute care hospitals.

Chronic care:

- To increase the independence of disabled and elderly persons.

Industry

- To promote and assist industry in the development of new products and processes for health care.
- To provide scientific data in support of the safe use of technology in health care.

Biomedical science and technology involves a broad range of disciplines and consequently the interrelationships between divions and laboratories is quite complex. The Program description provides the detailed objectives of each identified program element.

3.0 PROGRAM DESCRIPTION

3.1 HABILITATION/REHABILITATION

Objectives

- To improve the quality of life of the physically handicapped, developmentally delayed, and elderly persons through the design, development, evaluation, and application of devices and technology which will address the problems associated with disability.

- To apply and develop technology and engineering expertise to address the problems associated with disability. To develop cost-effective technical aids and devices to enhance the possibilities for employment and independent living.

- To stimulate thought and action in areas of rehabilitation science research and development.

- To support goal-oriented R&D which brings a coordinated and comprehensive approach to problems associated with disability.

Significance

Institutionalization is by far the most expensive form of health care. Canada has the highest rate of institutionalization of the elderly of any western country: Canada 9.45%, United Kingdom 5%, United States 5.3%, and Australia 5.9%. If no changes are made in the present approaches to health care, our aging population will create a crisis situation. For example, by the year 2021 the elderly will require another 300 1000-bed long-term-care hospitals, contributing to an overall projected additional capital cost of $30.5B, and an increase in annual operating costs of $13.7B per year. The handicapped and developmentally delayed do not constitute as large a burden on society, but technology can permit cost savings and make dramatic improvements in their quality of life.

Activities

- Research

  The research program has been built upon the expertise within the Electrical Engineering Division, electronic instrumentation, computer applications and robotics. A collaborative program, to make micro-computers useful to the physically and mentally handicapped, has been conducted with rehabilitation centres across the country. A new project has been initiated to explore the application of robotics technology for home care.

- Commercialization

  The small fragmented market for technical aids makes it difficult to commercialize many products which address socially critical needs. The Rehabilitation Technology Unit of NRC provides assistance in the commercialization of such products on a national basis. Term support for the marketing agency, Technical Aids and Systems for the Handicapped Inc., provided a model for accelerating private sector participation.

Future Directions

More attention will be directed to technology which will focus on the needs of the elderly and the developmentally delayed. The technologies will be microcomputer based and will consist of memory aids, environmental controllers, communication systems, computer interfaces, intelligent orthotics and robotics.

A Canadian Rehabilitation Sciences Institute (CRSI) has been proposed by the Associate Committee on R&D for Rehabilitation of Disabled Persons. Funding would be sought from a variety of sources external to NRC to support Institute and its programs. The function of the Institute would be to stimulate activity in areas where inadequacies currently exist, as well as to enhance application and diffusion of devices and technology. The Institute is envisioned as the rehabilitation science community equivalent to the Canadian Institute for Advanced Research (CIAR). The Institute, through grants, will support a Canada-wide network of University Chairs, Centres of Excellence, fellowships and studentships. The initiation of such an Institute could provide valuable direction to the NRC program in this area.

3.2 MEDICAL DEVICES

Objectives

- To design, develop and evaluate medical devices and materials necessary for acute and chronic health care.

- To promote and assist industry in the development of new products and processes for health care.

Significance

Canada must, as noted in the body of the "Cost Containment" proposal, reduce its dependence on foreign products. We must address this problem by improving our ability to commercialize new products which are developed by our medical research industry. There is, however, an additional problem which must be addressed. Many products of critical value to the disabled and elderly or medical devices of benefit to specialized patient groups (orphan products) are not commercialized by the private sector because of fragmented markets. A public-private sector consortium approach could succeed when the benefits of such products to the overall health care system warrant public support. The lack of a significant Canadian medical manufacturing sector makes it clear that a national strategy must be developed to create viable business opportunities.

Activities

- Research

Scientific and clinical instruments are developed, in collaboration with industry, in support of the biomedical science projects within NRC. The non-invasive diagnostic and therapeutics projects have achieved world recognition with regard to the use of radiation modalities in medicine. Through its broad range of expertise in instrumentation, computer applications and biophysics, NRC has been able to support this research and contribute to product development.

The underlying principles which contribute to bone and joint implant failure are being studied collaboratively with external orthopedic research programs. Expertise in structural analysis at NRC has contributed to the development of a biomechanics facility directed at understanding the mechanical factors in bone remodeling and implant compatibility.

- Commercialization

Diagnostic ultrasound instrumentation for specialized application such as opthalmic surgery and coronary angioplasty have been developed and commercialized.

Specialized probes for experimental magnetic resonance (MR) investigations were developed in conjunction with a Canadian entrepreneur. Because MR instruments are increasing in clinical usage, these technologies have significant potential.

A line of spinal instruments and implants have been developed at NRC and are now being manufactured under licence from Canadian Patents and Development Limited and exported in collaboration with a multinational orthopedic manufacturer.

Future Direction

There are numerous medical devices (instruments, implants and implant materials) which have been developed in the Canadian medical research community which were subsequently manufactured and marketed by foreign sources. A national commercialization strategy is required to transfer biomedical technology to Canadian industry. The NRC will develop a medical devices group to assist with the transfer of technology from both NRC laboratories and other medical research groups to the private sector. It will take the form of an enterprise for the development, evaluation and commercialization of medical devices (instruments, implants, and implant materials).

It is anticipated that new product demands will arise out of the cost containment initiative. In support of such new activity this group will also be accessible to other related Canadian medical research programs. The Medical Devices program would seek to enhance collaboration between NRC expertise and the medical research community.

3.3 NON-INVASIVE DIAGNOSTIC AND THERAPEUTICS

Objectives

- To develop instruments, protocols and scientific data in support of the application of ionizing and non-ionizing radiation for diagnostics and therapeutics.
- To provide primary measurement facilities for ionizing and non-ionizing radiation in support of safety standards.
- To experimentally generate scientific data on the biological effects of acute and chronic exposure to non-ionizing radiation, including ultrasound, laser light, microwaves, high voltage, and high current electrical fields.

Significance

The practice of medicine has abeen transformed by increasingly less-invasive options for diagnosis and treatment. Early and accurate diagnosis is a critical element in reducing the severity of illness and disability, and ultimately reducing costs to society. Cost contaimnment can be achieved by using less labor-intensive laboratory testing techniques, and by enhancing the capabilities of less highly trained health-care workers.

However, to ensure the health and safety of Canadians exposed to modern diagnostic and treatment modalities in medicine and in occupational environments, safety standards are essential.

Standards, related to the biological systems include not only the ways and means of measuring the physical parameters of the radiation or illumination but also involve basic studies on the effect of this intervention on the biological system.

The scientific research required to support this activity must delineate both measurement techniques (to quantify dosage) and data indicating the effect of this intervention on the biological system.

Activities

- Research

NRC has been a forerunner in the development of non-invasive diagnostic protocols to improve the spectroscopic and imaging capabilities of magnetic resonance technology. The potential of this technology to contribute to clinical practice is only beginning to be realized in such areas as cancer diagnosis and preservation of organs for transplant.

Ultrasound is the most widely used fetal imaging energy. Studies of the effects and uses of ultrasound to understand the basic mechanisms of action on both the cell and whole organ levels particularly with respect to heart and brain tissues are required to ensure no adverse long term effects are possible.

Laser angioplasties are being developed to provide less invasive treatment of specific heart diseases. This applicaiton of NRC's laser expertise may lead to a reduction in the need for or risk in open heart surgery.

Microwave radiation has been explored for the hyperthermic treatment of cancer. This expertise has been transferred to the private sector.

A feasibility study estimating bone strength by the integration CAT scan data with mathematical structural models to measure the effects of osteoporosis, has been completed.

- Commercialization

The instrumentation and medical devices developed through this program have been transferred to the private sector as described in the medical devices program element.

Specialized services have been developed such as calibration facilities for both ionizing and non-ionizing radiation.

Future Directions

It is proposed that a Non-invasive Diagnostics and Therapeutics Laboratory, be established to coordinate the research in this area.

- It would lead to a marketable service which would reduce hospitalization by increasing specificity of treatment and reducing complication rates.

3.4 IMMUNOCHEMISTRY

Objectives

- To develop vaccines for the prevention of bacterial diseases.
- To develop low cost diagnostic kits for public health screening.

Significance

The most effective means of containing health care costs is the prevention and early diagnosis of diseases and disabling conditions. Vaccination, prevents the spread of disease, eliminates all related hospital costs. Research programs which are successful in introducing new vaccines are an important resource. The early detection of disease through simple diagnostic kits not only serves the public health programs in Canada but also benefits third world countries without the resources and expertise to develop such products.

Activities

- Research

  Research in this group involves the growth of pathogenic bacteria for the extraction, isolation and identification of specific antigens; determination of the structures of the antigens; preparation of polyclonal or monocloncal antibody to the antigens; identificaiton, by serology, of oligosaccharide determinant groups and their synthesis. This facility is national and in conjunction with the analytic capabilities in NRC, has led to the development of vaccines and diagnostic kits for bacteria which are significant public health problems.

- Commerical

  The development of hybridoma technology has been transferred to the private sector for the production of monclonal antibodies to blood group substances.

  New patent diagnostic kits have been licensed for transfer to the pharmaceutical industry.

Future Directions

Further research is required to immunologically characterize the various strains of pathogenic bacteria currently under study.

Testing of human vaccines has been a significant problem from liability perspective. A national strategy must be developed to ensure Canada will be able to continue to develop preventative health care measures.

3.5 DISEASE MECHANISMS AND BIOLOGICAL PROCESSES

Objectives

- To discover underlying mechanisms of cell behaviour which are critical to the prevention and management of disease.

Significance

Cancer is one of the leading causes of mortality and morbidity in Western Societies. Treatments are usually lengthy, un-pleasant, and expensive. To improve this circumstance a better understanding of those factors which control normal and abnormal cell proliferation must be determined.

Activities

- Research

  Research being conducted on the role of calcium and calcium-binding proteins in the mechanisms of proliferation of normal and cancer cells has led to the discovery of a new cancer-specific, calcium binding protein, oncomodulin. A model rat cell system is being used to search for more cancer-specific cellular products for cancer detection and for clues to the origin of cancer.

- Commmercialization

  Oncomodulin is being developed as a cancer diagnostic in collaboration with a pharmaceutical company.

Future Directions

Future research will continue to explore the calcium controlling mechanisms in cancer cells, the contribution of oncomodulin to cancer cell behaviour and cancer-related products which appear in the model cell system.

4.0 IMPLEMENTATION

The Biomedical Science and Technology Program will utilize the existing divisional organization. Fiscal management will continue to flow through the Vice Presidents and Divisional Directors for the implementation of research projects. A Program Coordinator will be appointed to provide a focus for the laboratory activities and to persue new resources and research opportunities.

The core of the program will be based upon the Laboratory for Biomedical Engineering and the Medical Biosciences. Planning of research objectives across the program will be determined between these directors and the coordinator.

External resources will be sought from both the Cost Containment Initiative and the Rehabilitation Institute. The coordinator will be responsible for negotiating use of these research funds within and outside of the NRC to meet the stated objectives.

An annual report will be prepared through the coordinator to summarize the program activities and future plans.

APPENDIX M

OVERVIEW OF AN ON-LINE BEDSIDE WORKSTATION

OVERVIEW OF AN ON-LINE BEDSIDE WORKSTATION

Vancouver General Hospital

In the spring of 1985, the Division of Nursing at Vancouver General Hospital, in collaboration with the Information Systems Department and the Biomedical Engineering Department, began to develop a prototype of an electronic bedside nursing documentation system capable of collecting clinical data, processing these data and displaying the information in both screen and printed formats. Capture of patient data at the bedside was the primary thrust of the project.

It was envisioned that a portable workstation capable of capturing, processing, and displaying data and that could be carried by the nurses, would be an important first step in the creation of an electronic lifetime clinical record. Electronic data capture at source will improve patient care by providing legible, consistent, integrated, timely, and easily accessible clinical patient data. In addition, at source data capture will improve nursing productivity.

A crude portable workstation prototype was built and demonstrated on several nursing units. Feedback on the prototype's ability to meet the needs of nursing was obtained. The demonstration of clinical data collection and display at the bedside was well received by the nurses.

Phase II of the workstation project began in late 1986. The main objective of Phase II was to build a prototype of a functionally complete nursing data capture and data display software system that could be implemented, tested, and evaluated on an active nursing unit. It was determined that the definition of the functionality required by nursing would take priority since the development of portable technology was being pursued by computer hardware companies. Definition of the on-line functions, programming of those functions, and production of hard copy reports were completed in the spring of 1988.

Phase III of the workstation project will involve the installation and evaluation of the bedside documentation system on an active surgical nursing unit at Vancouver General Hospital. The major objectives of the Phase III of the project are to evaluate the functionality of the system; to determine the impact of the system on the organization and administration of care on the unit; to compare the time taken by the nurses to document nursing care with and without the system; to demonstrate that the presence of an automated bedside documentation system will result in nurses and other professional staff referring to patient clinical data more frequently; and to evaluate the acceptance of the bedside monitor by patients and health professionals.

SUMMARY OF RECOMMENDATIONS
FROM ALL SECTORS

AGRICULTURE AND FOOD PROCESSING

PRIMARY AGRICULTURE
- ROLE OF AGRICULTURE CANADA
- VERY SMALL AVAILABLE LAND BASE

SECONDARY MANUFACTURE
- POTENTIAL GROWTH AREA

FOOD PROCESSING
- POTENTIAL GROWTH AREA

RECOMMENDATIONS

- INTERFACE WITH BIOTECHNOLOGY
  - DISEASE CONTROL
  - GENETICS
  - WASTE MANAGEMENT

- VALUE ADDED
  - FOOD PROCESSING

- INCREASE PRODUCTIVITY

- INCREASE INDUSTRY INVOLVEMENT
  - CO-OPERATIVE RESEARCH

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AGRICULTURE AND FOOD PROCESSING

RECOMMENDATIONS (CONT'D.)

- FUNDING FOR SECONDARY MANUFACTURE, FOOD PROCESSING
- RESEARCH ORGANIZATIONS STAFFING AND EQUIPMENT
- GENERAL AWARENESS
- TECHNOLOGY TRANSFER

AQUATIC RESOURCES

$750M INDUSTRY

AQUACULTURE - HIGH GROWTH
- SCIENCE ISSUES

RECOMMENDATIONS

- WATER QUALITY
  - SPECIFIC CONTAMINANTS
  - AQUACULTURE
- AQUATIC INSTRUMENTS AND DEVICES
  - INTERFACE WITH SECTOR
  - GROWTH AREA
- FISH HARVESTING
  - GOVERNMENT AND SOCIAL POLICIES
  - IMPROVEMENTS POSSIBLE
  - SHIP/SHORE COMMUNICATION

AQUATIC RESOURCES

RECOMMENDATIONS (CONT'D.)

- FISH PROCESSING
  - NEW PRODUCTS
  - BY-PRODUCTS
  - QUALITY
  - PACKAGING
- AQUACULTURE
  - INTERFACE WITH BIOTECHNOLOGY
    - DISEASE CONTROL
    - NUTRITION
    - GENETICS
    - WASTE MANAGEMENT
  - NETWORK OF EXCELLENCE

BIOTECHNOLOGY

EMERGING INDUSTRY - $12M

IMPACTS ON MANY SECTORS - FORESTS
- AGRICULTURE
- AQUACULTURE
- HEALTH
- WASTE MANAGEMENT
- MINING

NEED FOR STRATEGIC PLANNING, CO-ORDINATION

RECOMMENDATIONS

- FOCUS ON
  - DISEASE CONTROL
  - GENETIC IMPROVEMENT
  - WASTE MANAGEMENT
- STRATEGIC PLANNING - USE OF EXISTING COMMITTEE
- LONG TERM COMMITMENT OF FUNDING
- RAISE FUNDING FROM $10M TO $30M - 5-10 YEARS

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BIOTECHNOLOGY

RECOMMENDATIONS (CONT'D.)

- STRATEGIC RESEARCH, TRAINING, SCHOLARSHIPS
- INDUSTRY/UNIVERSITIES INTERACTION
- REVIEW FACILITIES NEEDS AND CO-ORDINATION

ENERGY

MAJOR RESOURCE OF PROVINCE

DEPENDENCE OF OTHER RESOURCE SECTORS

OIL - IMPORT TO B.C.

NATURAL GAS SURPLUS

RECOMMENDATIONS

- OIL & GAS
  - DEVELOP UNDERSEA ROBOTICS
  - PREPARE FOR SWITCH AWAY FROM OIL
  - NATURAL GAS DIESEL ENGINE CONVERSION
- COAL
  - DEVELOP CAPABILITY TO ANALYZE COALS
  - BENEFICIATION & TRANSPORTATION
  - ALTERNATIVE USES

ENERGY

RECOMMENDATIONS (CONT'D.)

- WOOD RESIDUE AND BIOMASS
  - CONTINUE DEVELOPMENTS - METHANOL, ETHANOL
- OTHERS
  - HYDROGEN
  - FUEL CELL

SCIENCE & TECHNOLOGY ENERGY FOCUS

- CENTRE FOR ENERGY STUDIES
- BUILD EXPERTISE
- UNDERTAKE TESTS
- NATURAL GAS
- LONGER TERM ITEMS

FORESTS AND FOREST PRODUCTS

GROWTH AREA

MOVING TO VALUE ADDED PRODUCTS

RESOURCE DIMINISHING AND MORE EXPENSIVE

WORLD-WIDE COMPETITION

DEPENDENCE ON SCIENCE & TECHNOLOGY

ADVANCED MACHINERY AND SYSTEMS

PEOPLE NEEDS

RECOMMENDATIONS

- OVERALL CO-ORDINATION FOR SCIENCE AND TECHNOLOGY
- ADD VALUE
- IMPROVE PRODUCTION FOR RESOURCE

FORESTS AND FOREST PRODUCTS

RECOMMENDATIONS (CONT'D.)

- RAISE TECHNOLOGICAL AWARENESS AND COMPETENCE
  - RESEARCHERS
  - 'RECEPTORS'
- TECHNOLOGY TRANSFER
- USE OF ADVANCED SYSTEMS, TECHNOLOGIES AND MACHINERY

INFORMATION TECHNOLOGY

$1 BILLION INDUSTRY

11,500 PEOPLE

25%-50% ANNUAL GROWTH

RESOURCE INDUSTRIES/INFORMATION TECHNOLOGY

PEOPLE NEEDS

CO-ORDINATED ACTIONS

RECOMMENDATIONS

- ENHANCE RESOURCE INDUSTRIES BY ENHANCING THE INFORMATION TECHNOLOGY INDUSTRIES
- COMMIT TO INFORMATION TECHNOLOGY
- MARKETING, MANAGEMENT, TECHNICAL PEOPLE
- CO-ORDINATION AND PLANNING ROLE
- INFRASTRUCTURE AND SUPPORT

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MANUFACTURING

IMPORTANCE TO PROVINCE

4,000 COMPANIES - 40 LARGE

LACK OF TRAINING

DIFFICULTIES OF LOCATING PARTNERS

TECHNOLOGY TRANSFER - SMALL COMPANIES

RECOMMENDATIONS

- STRATEGIC PLAN - 'CHAMPION'
- BIOMEDICAL DEVICES
- EDUCATION AND TRAINING
- TECHNOLOGY CENTRE
- RESOURCE INDUSTRIES - ROBOTICS
- NETWORKING
- CAD/CAM
- FUNDING

MINING, MINERALS, METALS

NEEDS

- INDUSTRY INVOLVEMENT
- NATIONAL CO-ORDINATION
- FOCUS ON R&D
- RAISING AWARENESS

RECOMMENDATIONS

- R&D CO-ORDINATOR FOCUSSED ON B.C. NEEDS, NATIONAL INTERFACE

- INDUSTRY CHAIRS - ADVANCED MATERIALS

- CENTRES OF EXCELLENCE:

  - ADVANCED MATERIALS
  - INDUSTRIAL MINERALS
  - GEOLOGICAL EXPLORATION
  - RARE & PRECIOUS METALS

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EMERGING THEMES

- BUILD ON EXISTING COMPANIES, ORGANIZATIONS AND INDIVIDUALS
- ORGANIZED STIMULATION OF INTERACTION AND PLANNING WITHIN AND BETWEEN SECTORS
- RESOURCE INDUSTRY FOCUSSED, TECHNOLOGY DRIVEN CENTRES OF EXCELLENCE
- VALUE ADDED PRODUCTS FROM RESOURCES USING TECHNOLOGY DEVELOPED IN B.C.
- DEVELOP THE MARKETING, MANAGEMENT AND TECHNICAL TALENTS OF OUR PEOPLE
- EFFECTIVE USE OF SIGNIFICANTLY MORE R&D SPENDING

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